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ENGINEERING FLIGHT TEST OF THE AH-1G HELICOPTER HUEYCOBRA

PHASE B
PART 1

FINAL REPORT

JOHN R. MELTON
PROJECT ENGINEER

GARY C. HALL
MAJOR, TC
U S ARMY
PROJECT OFFICER/PILOT

JANUARY 1968

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US ARMY AVIATION TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

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ABSTRACT

Part 1 of the AH-1G helicopter Phase B test was conducted at Ft Hood, Texas, from 3 April 1967 to 21 April 1967 by the U. S. Army Aviation Test Activity, Edwards AFB, California. The helicopter flying qualities were evaluated throughout the aircraft speed range for the Scout and Hog configurations at a mid-center-of-gravity location. Flying qualities were also evaluated during weapons firing and external stores jettison. The primary deficiencies detected during this test were stability and control augmentation system (SCAS)-pylon coupling, inadequate in-ground-effect (IGE) directional control power, undue pilot attention required to avoid exceeding the torque limits of the helicopter transmission in dives and left rolls with fixed collective, and an inadequate, illogical fire control system. Other shortcomings were detected, such as airspeed system errors, degradation of flying qualities with SCAS off, static lateral cyclic control force imbalance, and marginal cockpit ventilation. Helicopter reactions to weapons firing and external stores jettison were satisfactory, and the contractor approved flight envelope for firing and jettison was acceptable.

FOREWORD

During the conduct of the AH-1G helicopter Phase B test at Ft Hood, Texas, the helicopter and special instrumentation were maintained by Bell Helicopter Company personnel under contract. U. S. Army firing ranges, hangar, and office facilities were utilized at Ft Hood, Texas.

INTRODUCTION

BACKGROUND

1. Phase B engineering flight testing of the AH-1G helicopter is planned to be accomplished using several test aircraft, during different time periods. Testing of stability and control characteristics in the Scout and Hog configurations, firing of the TAT-102 chin turret and wing mounted armament systems and jettison of wing stores were accomplished using AH-1G helicopter S/N 66-15246. This report presents the results of those tests. Stability and control tests in the basic configuration will be accomplished using AH-1G helicopter S/N 66-15248. The results of those tests will be presented in part 2 of this report under a separate cover. Firing tests of the XM-28 chin turret will be done (following qualification of this armament subsystem) using AH-1G helicopter S/N 66-15283. The results of those tests will be presented in parts 3, 4 and 5 of this report under separate covers. Performance tests will be done using AH-1G helicopter S/N 66-15247. The results of those tests will be presented in part 6 of this report under a separate cover.

TEST OBJECTIVES

2. The objectives of this test were to provide flight test data to:

a. Verify or modify the contractor proposed flight envelope for future service tests, logistical tests and operational use.

b. Define and allow early correction of helicopter deficiencies.

c. Provide a basis for evaluation of changes incorporated to correct deficiencies.

d. Estimate the degree to which the helicopter is suitable for the intended mission.

DESCRIPTION

3. The test aircraft, serial number 66-15246, was the second prototype AH-1G tactical helicopter produced by Bell Helicopter Company designed specifically for the combat role. It is a tandem, two-place, high speed conventional helicopter with a two-bladed door hinge type main rotor and conventional

pusher anti-torque rotor mounted on the left side of the helicopter. A three-axis stability and control augmentation system (SCAS) is used (in lieu of the stabilizer bar) to improve helicopter stability and handling qualities. The test helicopter is powered by a Lycoming T53L-13 turboshaft engine rated at 1400 shaft horsepower (shp) at sea level (S.L.) standard-day static conditions. The powerplant is derated to 1100 shp at 314 RPM rotor speed due to maximum torque limits of the helicopter main transmission. The distinctive features of the helicopter are the narrow fuselage (36 inches), the stub mid-wings with 4 external stores stations, and the integral chin turret. The armament configurations are changed by varying wing stores. The pilot can fire all weapons in the stowed position. The copilot/gunner operates the flexible turret and can also fire the wing stores in an emergency by use of the pilot override. The flight control system is a positive mechanical type with conventional helicopter controls in the pilot's aft cockpit. The copilot/gunner's forward cockpit is provided with sidearm collective and cyclic controls. Control forces are reduced by hydraulic servo cylinders connected to the control system mechanical linkage. The hydraulic system is powered by dual transmission-driven pumps. A synchronized elevator is used to increase static longitudinal stability and lengthen center of gravity (C.G.) range. An electrically operated mechanical force trim system connected to the cyclic and directional controls is used to induce artifical control feel and positive control centering. Ausform Armor protection is provided for the crew, engine fuel control, and engine compressor section. A complete aircraft description is included in references 4 and 9, and aircraft dimensions and design information is presented in appendix III.

SCOPE OF TEST

4. Part 1 of the AH-1G helicopter Phase B Test was conducted at Ft Hood, Texas, and consisted primarily of stability and control testing in the Scout and Hog configurations (see table 1) and handling qualities evaluations during weapons firing and jettison tests. Noise level and vibration surveys were also conducted. Detailed monitorship of the contractor's jettison and firing tests by U. S. Army Aviation Test Activity (USAAVNTA) personnel greatly reduced the scope of the Army, Phase B firing and jettison tests. Since this test by necessity preceded the contractor's handling qualities investigation in which tail rotor effectiveness will be investigated and since the prototype test helicopter was not equipped with standard illumination equipment, the tail rotor effectiveness

test and night flight evaluation included in the Plan of Test (reference 8) were deferred to the Phase B test on AH-1G helicopter S/N 66-15248. Thirty flights were flown for a total of 46.0 test hours during an elapsed calendar time of 18 days. Tests were conducted with gross weight (G.W.) variations of 6804 lb to 9430 lb. The configurations used are presented in table 1. The flight restrictions which governed these tests were obtained from the contractor and are presented in appendix IV.

Table 1. Test Configurations.

Configuration	Armament Subsystems
Clean	TAT-102A turret
Basic	TAT-102A turret, one XM-157 outboard each wing
Scout	TAT-102A turret, one XM-18 inboard, one XM-157 outboard each wing
Hog	TAT-102A turret, two XM-159 each wing
Alternate	TAT-102A turret, one XM-159 outboard each wing

The XM-134 minigun 7.62 machine gun is an integral part of the TAT-102A turret.

METHODS OF TESTS

5. The methods used in these tests were standard engineering flight test methods and are described briefly for each test in the Results and Discussion Section of this report.

CHRONOLOGY

6. The chronology of this test program was as follows:

Test helicopter received, Ft Worth, Texas	3 April 67
Flight testing commenced, Ft Hood, Texas	6 April 67
Flight testing completed, Ft Hood, Texas	21 April 67
Test helicopter returned to contractor's facility, Ft Worth, Texas	21 April 67
Draft report submitted	21 June 67
Final report forwarded	February 68

RESULTS AND DISCUSSION

PILOT'S PREFLIGHT INSPECTION

7. The pilot's preflight inspection procedure recommended by the contractor appeared to be satisfactory. The tail rotor 90 degree gearbox inspection port was not transparent, which prevented visual inspection of the gearbox fluid level. This condition has been noted on all four AH-1G helicopters available for inspection. It appears that the plastic window in the inspection port was painted over in the manufacturing process, and when the paint was removed the transparency of the plastic was destroyed. This deficiency must be corrected to allow proper preflight inspection.

COCKPIT EVALUATION

Pilot's Cockpit

8. Ingress and egress of the pilot's cockpit was easy using the leather handholds and steps that were provided on the right side of the aircraft. Elimination of the handholds will make this procedure unacceptable. In addition, a helmet hook within the cockpit for stowing the pilot's helmet during entrance and exit is absolutely mandatory since no other location is available for the helmet.

9. The pilot's seat was very comfortable, enhanced the mission capability of the aircraft, and should reduce pilot fatigue considerably. The Ausform Armored seat was not

installed in the test aircraft. This seat will be evaluated on helicopter S/N 66-15248. Directional control pedals were adjustable and appeared to have adequate range of adjustment. The adjustment knob should be larger to allow easier operation by the pilot. Seat adjustments appeared to be adequate.

10. The canopy hatch hold-open and locking mechanism was not adequate. Unless undue care is exercised, the canopy hatch can fall and cause minor injuries. Caution must be exercised in leaving the canopy hatch open when other helicopters are operating close to the aircraft. On several occasions the canopy has blown off by rotor wash from other helicopters.

11. The master caution panel and the chip detector lights were mounted on the right side pilot's console. This location made it difficult to identify illuminated caution lights with direct sunlight shining on them through the canopy. The caution panel and chip detector lights should be relocated where the glare shield can function to protect those critical items from glare.

12. Instrumentation locations appeared to be adequate. The attitude gyro did not present usable information. A new type attitude gyro should be provided which presents a true picture of the aircraft's attitude. Until this is done the aircraft will be unsuitable for prolonged instrument flight. The ball in the turn and bank indicator, on the test aircraft, vibrated within the race severely during high speed dives and moved to the left in the race two ball widths and stuck, although balanced zero sideslip flight was maintained using the sideslip indicator with the turn needle centered. This problem should be investigated because recurrence without a sideslip indicator could result in exceeding the helicopter sideslip limits.

13. The primary ultra high frequency (UHF) radio was located in the center of the pilot's instrument panel and was easily operated with the left hand. The armament switches that are not on the cyclic control and frequently used avionics switches should be located so they can be operated with the left hand, since removal of the right hand from the cyclic control for any length of time is not advisable.

14. The pilot's armament fire control system is unsatisfactory in its present configuration. The two-position "master-armed" switch, when placed in the armed position, does not arm any subsystem on the aircraft, yet a light comes on which indicates the firing circuits are activated. This light

indicates the TAT-102A turret and the XM-18 minigun pods, if installed, are in standby. To arm the system, the turret switch must be positioned to pilot or gunner, and the wing stores switch must be positioned to inboard or outboard. When turret is selected a blue light comes on to indicate that the turret is armed. When wing stores are selected an amber light comes on to indicate wing stores are armed. The present two-position master armed switch should be replaced by a three-position lift to operate lever lock switch with the following positions:

a. "Off" - All armament subsystems off.

b. "Safe" - All armament subsystems placed in a standby status; power is supplied to the turret to allow system check-out but firing circuit is not armed. Power is supplied to the wing stations to permit charging of the XM-18 batteries, and any armament subsystem installed is activated with the exception of its firing circuits.

c. "Armed" - This switch position arms the firing circuit of the turret or wing stores selected by the pilot.

d. Warning lights - "Safe" - Green light which indicates that all systems are placed in standby but firing circuits are not activated. "Armed" - An amber light which indicates that all selected armament subsystems firing circuits are activated and will fire when the trigger switch is activated.

e. Turret power switch can be deleted if the above switch is installed. The present turret control switch should have only pilot or gunner positions, no "off" position. The blue light should be retained to show which station has turret control.

15. In the present cockpit configuration, wing stores jettison is accomplished by switches. If selective jettison is required, the spring loaded two-position wing stores jettison selector switch is placed in either "inboard" or "outboard" position releasing the selected stores. If salvo of all wing stores is desired a guarded switch on the instrument panel must be activated. This requires the pilot to remove his hands from the controls at a critical time to salvo the wing stores. The wing stores jettison selector switch should be replaced by a lift-to-operate, three position switch. Switch positions should be "inboard", "outboard", and "all". The switch will normally be in the "all" position. This will give the pilot the capability of im-

mediate action should salvo jettison be required. Selective jettison may be accomplished in a less urgent situation. It is mandatory that the jettison switch be located on the cyclic control stick. During an emergency situation, the pilot will be occupied in controlling the helicopter and can not remove his hands from the cyclic. This requirement seems quite obvious since for both the contractor and USAAVNTA jettison tests the system had to be modified to allow the stores to be jettisoned by a button on the cyclic control stick.

16. The pilot's cyclic stick grip is the same as that provided with the current production UH-1 series aircraft, and is intended for production with the AH-1G helicopter. The pilot's cyclic stick employs two unguarded switches to fire the weapons subsystems. The index finger operated trigger switch is used to fire the TAT-102A turret and a thumb operated button is used to fire the preselected wing stores. This is confusing and unnecessarily requires the pilot to make the selection twice, once at either the turret control panel or wing stores control panel and again at the cyclic grip. The index finger operated trigger switch should be a guarded two-position switch which fires the subsystem selected on the pilot's armament panel and should be the only firing switch. The first position should be low rate if TAT-102A is selected and gunner interrupt if wing stores are selected. The second position should be high rate if TAT-102A is selected or wing stores are selected. The thumb operated switch which is presently the force trim release on the top left of the cyclic should become the jettison switch. The present wing stores firing button should become the force trim release. This is where the thumb rests naturally on the grip, and the force trim release is used continuously.

17. The pilot's armament system sight was not evaluated since it was not installed. Cockpit preflight procedure outlined by the contractor was adequate, and starting procedure was simple and basically the same as that of the UH-1 series helicopters.

Copilot/Gunner's Cockpit Evaluation

18. Entry and exit techniques from the copilot/gunner's station were acceptable, but considerable caution was required. The fixed step and handholds were well located, but both hands were required. In the absence of helmet hooks, the helmet must be handed in after entry, worn while entering, or placed on top of the instrument panel where it would scratch the center panel of the canopy and blur the frontal field of vision. The center panel of the canopy of the test helicopter

sustained scratches and marring to the extent that forward visibility was restricted. During ingress and egress of the copilot/gunner's cockpit, it was difficult to avoid head contact with the canopy jettison handle.

19. The copilot/gunner's cockpit was provided with a standard two-position lever-lock switch to select fuel control automatic or emergency. This switch was located on the miscellaneous control panel on the left side where an entering or exiting crew member was required to climb over it. The lift-over-center lever-lock protection feature is unsatisfactory for a switch located in this vulnerable position. A protective device that will retain the switch in the "auto" position under the impact of an inadvertent kick is mandatory.

20. The rotor speed select (beep) switch was located on the left side panel near the collective pitch control. The beep switch could not be reached while making collective pitch changes when it was most required. The beep switch should be moved to its proper location on the collective stick.

21. The turret sight appeared adequate; however, accuracy and reliability evaluations were not within the scope of this test. When the sight was stowed on the stowing mount in the forward right corner of the cockpit, leg and knee room was severely restricted. This made entering and exiting the cockpit considerably more difficult than when the sight was removed. The azimuth stow locks and stow mount lock for the turret sight presently must be identified and activated by feel alone. Stowing the turret sight in flight was difficult because of interference with the right leg, and because of the location of stow locks.

22. The nonadjustable armored seat was quite comfortable; however, experience has indicated that different thicknesses of seat cushions are required for optimum body positioning. Changing cushions, along with the adjustable directional control pedals, appears to provide an acceptable range of positioning adjustment.

23. The copilot/gunner's flight controls, sidearm cyclic and collective, and conventional directional control pedals were excellent in concept. Flight from the front cockpit was performed from a hover to V_L both SAS on and off. The static lateral cyclic control force dissymmetry described in paragraph 69 and figure 42 of this report was particularly objectionable on the sidearm cyclic of the forward cockpit. The steady right force required had to be exerted by the

extended forearm which proved to be uncomfortable after a short period of time. The hardware to adjust control system friction and select force trim on or off was not available in the front seat. These functions were not essential to emergency operation which is considered the normal mode for use of the copilot/gunner's controls. Adjustment to full increase of the cyclic friction in the aft cockpit did not preclude forward cockpit control of the aircraft, although control forces were uncomfortably high.

Cockpit Ventilation

24. The ventilation system of the test aircraft consisted of a flush mounted, adjustable outlet in the right side of the instrument panel and deck outlets on each side. Ram air was boosted by an electrically driven blower through these outlets. Average ambient temperatures for the test program were between 80 degrees - 90 degrees F. With the blower on, the helicopter's ventilation system was marginally adequate for the mild ambient conditions encountered during this test program. Without the blower system, the cockpit conditions rapidly become hot and stifling. Based on experience from the Republic of Vietnam (RVN) it was concluded that pilot and copilot/gunner fatigue will be greatly increased due to an inadequate helicopter ventilation system.

AIRSPEED CALIBRATION

25. Airspeed calibration flights were conducted to determine the position error of the test (boom) and ship's standard airspeed systems. A trailing bomb was utilized as an airspeed reference up to 107 KIAS. The indicated airspeeds of the test aircraft were compared with the calibrated airspeeds from the trailing bomb. From 90 to 182 KIAS a T-28 airplane (pacer aircraft) with a calibrated airspeed system was utilized as an airspeed reference. The indicated airspeeds of the test aircraft were compared with the calibrated airspeeds of the pacer aircraft. Calibration of both the boom and ship's standard system was conducted in the Basic and Hog configurations, in level flight, dive, climb, and autorotation. The test results are presented in figures 1 and 2.

26. The results of the standard system calibration do not agree with the airspeed calibration used by the contractor. Up to 160 knots indicated airspeed, agreement was within 2-1/2 knots. The difference was in the direction such that a "calibrated" airspeed of 180 knots in the contractor's

airworthiness qualification test reports was actually 174 knots. Provided that the contractor is consistent within his own system of airspeed calibration, the results of his airworthiness qualification reports should be valid for an adjusted airspeed.

27. The contractor's proposed indicated limit airspeed of 180 KIAS was a realistic limit for service use of the helicopter at heavy weight in the Hog configuration, regardless of the actual calibrated airspeed. At 180 KIAS (174 KCAS) the helicopter pitch attitude, rate of descent, noise level, and vibration level were increasing rapidly. It is doubtful that any actual service limitations will be realized because of this airspeed discrepancy.

STABILITY AND CONTROL

Static Longitudinal Stability

28. Static longitudinal stability tests were conducted to define the flight control position requirements as a function of airspeed and to evaluate the collective-fixed static longitudinal stability of the helicopter. At each trim point the collective-fixed static longitudinal stability was defined by maintaining the collective pitch control fixed at the trim condition and recording control position requirements at stabilized increased and decreased airspeeds from the trim airspeed. Each trim point of a series was flown at a constant thrust coefficient (C_t). The helicopter was stabilized at a trim airspeed and data was recorded to determine the control positions. This data defined the control position requirements as a function of airspeed for those trim conditions tested. These tests were conducted for three configurations and the test results are presented in figures 3 (Hog), 4 (Scout), and 5 (Clean) of appendix I.

29. Longitudinal cyclic position requirements were positive. Forward cyclic was required to increase airspeed at most conditions tested. Although the static longitudinal stability was positive, the gradient at high airspeeds was shallow and nominal pilot attention was required to maintain a constant airspeed during high speed dives. Any decrease in the positive static longitudinal stability gradients at high airspeeds would be unacceptable, and an increase in the stability gradients at high speeds is recommended. Figure 5, appendix I, shows that in the clean configuration at high altitude with an aft C.G., longitudinal cyclic gradients were neutral at a trim airspeed of 129.5 KCAS. In all configurations tested, increased left lateral cyclic was re-

quired with increased airspeed. This characteristic was not considered objectionable to the pilot.

Static Lateral-Directional Stability

30. The static lateral-directional stability characteristics and effective dihedral were determined by stabilizing the helicopter at a trim airspeed, in balanced, zero-sideslip flight, with collective pitch control fixed. While maintaining a straight flight path over the ground and trim airspeed, sideslip angle was increased in increments. At each increment of sideslip, the control positions, helicopter attitudes, and sideslip angle were recorded. The test results are presented in figures 6 through 9 of appendix I. For all conditions tested, the static lateral-directional stability was positive. Increasing left sideslip required increasing right directional pedal and increasing left lateral cyclic. The gradients were essentially linear on either side of trim. Effective dihedral was positive and strong as evidenced by the increasing cyclic control requirement with increasing sideslip angles. Effective dihedral strength increased with increased airspeed. At all airspeeds, adequate warning was provided the pilot to allow him to easily maintain trimmed flight and execute coordinated maneuvers. The static lateral-directional stability characteristics and effective dihedral were satisfactory and enhanced the suitability of the AH-1G for its intended mission.

Dynamic Longitudinal Stability

31. Tests were conducted to insure that no unsafe dynamic stability characteristics existed within the contractor-approved flight envelope. These tests were conducted by disturbing the helicopter from trimmed stable flight with a one-inch, one-second control pulse simulating a gust input, and recording the resulting helicopter motions. The tests were conducted for the Hog configuration with a mid C.G., 324 rpm, at airspeeds from a hover to limit airspeeds. All quantitative tests were done with the SCAS on.

32. Longitudinal dynamic stability was excellent at all conditions tested. A longitudinal pulse resulted in a rapid excursion from trim with the input and a quick restoration of trim conditions when the controls were neutralized. Pitch rate was non-oscillatory. Pitch attitude made one excursion in the direction of the input and returned to trim.

33. A degree of lateral coupling was evident with longitudinal inputs. The helicopter would roll right with forward inputs and roll left with aft inputs. Under most conditions this coupling was not objectionable to the pilot due to the damping of the lateral SCAS.

Dynamic Lateral-Directional Stability

34. Dynamic lateral-directional stability tests were conducted to determine the lateral-directional damping and dynamic stability characteristics of the helicopter. Lateral-directional damping was defined by establishing trimmed zero sideslip flight at a selected airspeed. Without retrimming, the helicopter was placed in a stabilized sideslip. The controls were then released to return to their zero sideslip position, and the resulting helicopter motion was recorded. The characteristics of the angle of sideslip oscillations were analyzed to determine the dynamic lateral-directional damping ratio and damped natural frequency.

35. Figure 10, appendix I, shows the lateral-directional damping ratio as a function of both damped natural frequency and calibrated airspeed. Figure 11, appendix, I, shows a time history of one release from sideslip. Damping ratios were approximately 0.2, which is about half that value suggested by reference 2 as desirable for an armed helicopter. Figure 11, appendix I, shows that the yaw SCAS remained hardover for the entire maneuver. The roll SCAS actuator was hardover 35 percent of the time. During the time that the SCAS actuators were hardover, the helicopter was essentially SCAS-off with resulting decreased damping. The damping ratios obtained during these tests were considerably lower than those obtained in reference 5, when the SCAS configuration was not yet finalized. The SCAS actuators were not instrumented in reference 5, but it is probable that the differences in lateral-directional damping were due to differences in SCAS characteristics. It was not determined whether the characteristics of the yaw and roll SCAS, as shown in figure 11, appendix I, are abnormal or representative. Reflection on the method of test has shown that the release from a steady state sideslip may not be the optimum method of testing for lateral-directional damping because the maneuver is initiated from a somewhat abnormal condition. Upon release of the controls, the SCAS actuators are essentially null, and both the rate damping loop and the pilot control loop demand an initial SCAS travel in the same direction, which is a situation not normally encountered in flight. This will be investigated further in later AH-1G Phase B testing.

36. The AH-1G exhibited a roll oscillation which was most prominent at high power settings. Figure 36, appendix I, illustrates this oscillation. Under most conditions this oscillation was sufficiently damped by the roll SCAS not to be objectionable. The period of this oscillation was approximately two seconds. With the SCAS off, this two-second period roll oscillation was objectionable, but was not considered hazardous. This characteristic, perhaps more than any other, would limit the SCAS-off mission effectiveness of the helicopter. At high speed, high power conditions, the roll oscillation would greatly reduce the effectiveness of the helicopter as a weapons platform.

Controllability

37. Longitudinal controllability was evaluated by analyzing the helicopter motions following an abrupt longitudinal cyclic control displacement. Figure 16, appendix I, shows a typical time history of an aft longitudinal cyclic step input. Longitudinal response characteristics are summarized in figure 15, appendix I.

38. Longitudinal response at the high gross weight conditions tested during this evaluation was characterized by rather high time constants in the transient load factor. Time to reach 63 percent maximum load factor was approximately 1.5 seconds, while a target maximum time constant of 0.3 second has been suggested for this parameter by reference 5. This parameter basically describes the manner in which load factor builds following in abrupt longitudinal control input, which in turn affects the degree of precision with which the helicopter may be maneuvered. The load factor characteristics showed little or no "overshoot", which along with the high time constants indicated that the longitudinal SCAS was not ideally tailored in the relationship of rate damping and longitudinal quickening for the conditions tested. The pitch rate damping was also greater than optimum. Load factor characteristics following a longitudinal input showed a degradation compared to the results of previous Government tests. It is not presently known if this degradation is due to differences in helicopter configuration and gross weight during the tests, or due to internal changes in the SCAS. Longitudinal response tests are scheduled to be completed in a configuration similar to that of the original evaluation, reference 5, at a later date. These differences may be resolved at that time.

39. Lateral controllability was evaluated by analyzing the helicopter motions following a rapid lateral cyclic control input. Typical time history records of lateral step inputs are presented in figures 18 through 20, and lateral response characteristics are summarized in figure 17 of appendix I. In general, the lateral response characteristics greatly enhanced the suitability of the AH-1G as a weapons platform. Following a lateral step input, roll rate would increase rapidly and maintain a steady roll rate proportional to lateral stick displacement. This "rate steering" allowed is particularly important in a situation where weapons subsystems must be aimed by pointing the aircraft.

40. Two aircraft characteristics detracted from the otherwise excellent lateral response of the helicopter. The first, a left lateral input, resulted in a rapid increase in engine output power, which could result in a main transmission overtorque at high power settings. This characteristic is discussed further in paragraph 48.

41. The second aircraft characteristic which detracted from the lateral handling qualities was that an abrupt lateral input would excite the pylon motions discussed in paragraph 57. Depending upon the condition of the pylon dampers and the configuration of the roll SCAS, the pylon motion resulting from lateral inputs could range from imperceptible to extremely objectionable. The pylon motion would manifest itself as a periodic roll oscillation at a frequency of one-half cycle per rotor revolution superimposed upon the basic roll rate resulting from a lateral input. Figure 18 illustrates this characteristic. During this Phase B program, the pylon motion characteristic became unacceptable on the test aircraft, as discussed in paragraph 61, resulting in replacement of the pylon dampers. The pylon motion problems were reduced, but not eliminated by the new dampers. To reduce the pylon motion to an acceptable level, the contractor was forced to attenuate the roll SCAS damping. The result may be observed by comparing figure 19 to figure 18, appendix I. Figure 18 was taken before the pylon dampers were replaced and the roll SCAS was attenuated. The periodic roll oscillation was sensed by the SCAS and the SCAS attempted to damp the oscillation. This periodic SCAS input, however, had the effect of sustaining the pylon motion rather than damping the motion. Figure 19, taken after the roll SCAS rate damping was attenuated, did not exhibit this sustaining tendency. The pylon was disturbed initially by the cyclic input, however, with its reduced sensitivity, the SCAS did not counteract the motion. Although attenuating the roll SCAS rate,

damping did suppress the self-sustaining pylon motions, other effects of this change were undesirable, as discussed in paragraph 36.

42. The test helicopter suffered a lack of in-ground-effect (IGE) directional control power during the conduct of tests at high gross weight. Full left pedal was occasionally required to maintain heading in a hover. During the time available for the test, weather conditions did not allow a quantitative definition of pedal requirements as function of gross weight, density attitude, wind azimuth, and wind velocity; however, some qualitiative tests were done. While hovering over a point, at a three to five-foot skid height, hovering turns were made attempting to stabilize at heading increments. From these tests it was found that the most critical wind azimuth for pedal requirements was a left quartering tailwind (200 degrees to 260 degrees). A direct right crosswind was the second most critical condition.

43. During an attempt to define pedal position requirements in right sideward flight, at a gross weight of 9480 lb and a density altitude of 1800 ft, full pedal was required at airspeeds through the range of approximately 15 to 20 knots true airspeed (KTAS). The test conditions were not sufficiently controlled to define the precise airspeed range of inadequate directional control, but there was no question that at conditions within the existing flight envelope, sufficient IGE directional control power was lacking. The contractor has stated that final tail rotor rigging will be determined during the handling qualities tests yet to be performed. Changes made as a result of the contractor's handling qualities tests will be evaluated during later Phase B testing.

Maneuvering Stability

44. Tests were conducted to evaluate the maneuvering stability characteristics of the helicopter in terms of cyclic control stick force and position gradients as a function of load factor (g). Two test methods, wind-up turns and symmetrical pull-ups, were used. During the wind-up turns the helicopter was stabilized in 1.0 g level flight at a predetermined trim airspeed. Collective pitch control, power, and cyclic force trim were held fixed while the load factor was increased incrementally by establishing stabilized turns at various increasing bank angles, maintaining trim airspeed, and descending. Data was recorded during each stabilized bank angle increment. Maneuvering stability data was extended to higher load factors

using the symmetrical pull-up technique. In this test the helicopter was stabilized in 1.0 g level flight at the desired trim airspeed and altitude with all control forces trimmed to zero. While maintaining collective pitch, power, and cyclic force trim fixed, a cyclic pull-up was executed to gain altitude. The helicopter was pushed over into a dive and allowed to accelerate. Near trim airspeed, a symmetrical pull-up was executed so as to attain trim airspeed, altitude, and the desired load factor as the helicopter pitch attitude passed through trim. The results of these tests are presented in figure 22, appendix I.

45. For the limited conditions tested, the helicopter possessed both positive stick-fixed and stick-free maneuvering stability. An increasing aft (pull) stick force and an increasing aft stick displacement were required for an increased load factor. The longitudinal force gradient was due only to the springs of the artificial force-feel trim system. A positive stick-fixed (cyclic position) gradient automatically gave a positive stick-free (cyclic force) gradient.

46. During these tests cyclic control feedback was experienced during pull-outs. For the gross weight at which these tests were done, approximately 9100 lb, the onset of control feedback occurred at approximately 1.7 g's and remained until the g level was reduced by releasing the aft force on the cyclic. This phenomenon h d occurred in previous contractor tests and was due to the inadequacy of the lock-and-load check valves of the hydraulic servo cylinders. The contractor installed six spring-loaded ball check valves in the hydraulic system. This installation appeared to greatly reduce the problem, and 2.2 g pull-outs were made without cyclic feedback. These check valves are to be incorporated in production aircraft.

POWER MANAGEMENT

47. A particularly significant characteristic of the helicopter is illustrated in figures 3 and 4, appendix I. A lower collective pitch setting was required to maintain military rated power in a limit airspeed dive than at power limit level flight airspeed. When a dive was made from maximum cruise airspeed, collective had to be lowered or a transmission overtorque would occur. This condition was caused by normal engine governor action attempting to maintain rotor speed as airspeed, and thus profile rotor power required was increased in the dive. To avoid transmission overtorque under these conditions, either undue pilot attention is required during this maneuver or an engine torque limiter is required. Due to the mission

of this aircraft, the amount of pilot attention required to avoid transmission overtorque is considered unacceptable.

48. During flight conditions requiring 1100 shaft horsepower (shp), such as a full power climb or level flight at power limit airspeed, the left lateral controllability was limited by the main transmission torque limits. An abrupt left lateral cyclic input caused the rotor speed to decrease at a constant collective pitch setting. The engine N_2 governor would sense the rotor speed decrease and increase the fuel flow and thus the engine power. In order to avoid transmission overtorque in service use, either undue pilot attention is required or the aircraft must be equipped with a torque limiting device. This deficiency should be corrected prior to the helicopter's being deployed for operational use.

EXTERNAL STORES JETTISON

49. Three external stores jettison tests were conducted, in addition to monitoring the contractor's jettison tests, to permit the release of a jettison flight envelope for the AH-1G helicopter. The jettison tests accomplished are presented in table 2. Figure 26, appendix I, is a time history record of the jettison of dummy loaded XM-18 pods from the helicopter in the Scout configuration.

Table 2. Jettison Test Conditions.

External Store	Stores Stations	Store Configuration	Airspeed KCAS	Sideslip Angle Degrees	Flight Condition
XM-18	Inboard	Dummy (Ballasted to loaded weight and C.G.)	191	5	Dive
XM-159	Inboard	Empty	73	10	Autorotation
XM-159	Inboard	Partial Load	73	10	Autorotation

50. No stability and control or aircraft clearance problems were encountered during any jettison tests. During the contractor's asymmetric jettison of full XM-159 pods inboard at 130 knots indicated airspeed (KIAS) in autorotation, high roll rates indicated that asymmetric jettison of loaded XM-159 pods outboard could be a problem area. Until more data is available

on this potential problem area, jettison in autorotation of loaded XM-159 pods should be restricted to 100 KIAS. The results of the jettisons accomplished during this test coupled with the data collected during the USAAVNTA monitorship of the contractor jettison tests provide the basis for recommending release to the field of the external stores jettison flight envelope as presented in table 3. The AH-1G helicopter forced jettison system was efficient, very reliable, and is recommended for use on future Army armed aircraft.

Table 3. External Stores Jettison Flight Envelope.

External Store	Store Configuration	Airspeed - KIAS: Powered Flight	Airspeed - KIAS: Autorotation
XM-157	Full or empty Faired or unfaired	Hover to V_L	70-130
XM-18	Full or empty	Hover to V_L	70-130
XM-159	Empty unfaired	Hover to V_L	70-130
XM-159	Full, faired or unfaired	Hover to V_L	70-100

Note: External jettisons during uncoordinated flight, as much as one ball width out of center on the turn and bank indicator, can be satisfactorily accomplished at all of the above flight conditions. Balanced flight (turn and bank indicator ball centered) is recommended for all jettisons.

WEAPONS FIRING

51. Weapons firing tests were conducted to confirm the safe flight envelope within which weapon subsystems may be fired and to determine the effect of the weapons firing upon the helicopter handling qualities. These tests were conducted by stabilizing the helicopter at the desired flight conditions and operating the weapons system while recording the control movements required to maintain a constant helicopter attitude. Tests were conducted for the conditions shown in tables 4 and 5. Time histories of weapon firing are illustrated in figures 27 through 30, appendix I.

Table 4. Turret Positions.

Turret Position Number	Turret Position
1	Full up elevation, 90° left azimuth
2	Full up elevation, zero azimuth
3	Full up elevation, 90° right azimuth
4	Full down elevation, 90° right azimuth
5	Full down elevation, zero azimuth
6	Full down elevation, 90° left azimuth
7	Zero elevation, 90° left azimuth
8	Zero elevation, zero azimuth (Stow)
9	Zero elevation, 90° right azimuth

Table 5. Armament Subsystem Firing Conditions.

Armament Subsystem Fired	Turret Position No.	Config Ref Table 1	Gross Wt Lb	C. G. In.	Air-speed KCAS	Burst Time	Maneuver
TAT-102A	1,3,7, 8,9	Basic	7560 to 7980	194.7	Hover	4-6 Sec	
TAT-102A	1,3,4, 6,8	Basic	7330 to 7680	194.8	175	4-6 Sec	
TAT-102A	Traverse on target	Basic	7240	193.7	175	5 Sec	Left rolling pullout 2.16 load factor
TAT-102A	Traverse on target	Basic	7050	193.9	175	5 Sec	Right rolling pullout 2.06 load factor
XM-18	8	Scout	8910	195.0	Hover	5 Sec	
XM-18	8	Scout	8160	194.6	180	5 Sec	
XM-18	8	Scout	8740	193.7	178.5	5.6 Sec	Asymmetric Firing (left side only)
XM-157	8	Scout	8900	195.0	Hover	Full Complement Ripple	
XM-157	8	Scout	8810	195.2	179.5	Full Complement Ripple	
XM-159	8	Hog	8400	195.1	Hover	Full Inboard Ripple	
XM-159	8	Hog	9330	195.2	61.5	Full Outboard Ripple	
XM-159	8	Hog	8490	194.3	118	Full Inboard Ripple	
XM-159	8	Hog	7680	194.7	175	Full Outboard Ripple	
XM-159	8	Hog	8690	194.3	171	Full Inboard & Outboard Ripple	

52. At no time during these tests were any weapons firing reactions recorded which adversely affected aircraft stability or handling qualities. Aircraft reactions to firing were insignificant. The physical locations of the wing stores subsystems caused their thrust reactions to result in primarily linear accelerations of the aircraft rather than pitching, rolling, or yawing moments. At no time were stick margins inadequate or aircraft reactions objectionable due to weapons firing. The helicopter appeared to be a good stable weapons platform with the SCAS operative.

THROTTLE CHOP CHARACTERISTICS

53. Throttle chop tests were conducted to determine the reaction of the helicopter to sudden power loss or engine failure and to evaluate the recovery techniques recommended by the contractor. These tests were conducted by stabilizing the helicopter at the desired trim condition, and then simulating a sudden power loss by rapidly rotating the twist grip to the flight-idle position. The control trim positions were maintained until corrective action was considered necessary. These tests were conducted in the Hog configuration with an average gross weight of approximately 9100 lb at airspeeds up to 181 KCAS. Time histories of typical throttle chops are presented in figures 31 through 33, appendix 1.

54. The reaction of the AH-1G helicopter to a power failure at high speed, high power conditions was rapid and pronounced, requiring immediate positive corrective action by the pilot. Following a power failure at speeds greater than 130 KCAS, the helicopter immediately pitches, rolls, and yaws. The angular rates generated drive all three SCAS actuators hardover, counteracting these rates. Rotor speed decay rate is high at the high collective pitch settings required at these airspeeds. Minimum transient rotor speeds observed during these tests were generally between 250 and 270 RPM. In order to maintain flight rotor speed and to slow the helicopter to normal autorotation airspeeds, a firm cyclic flare must be initiated and held until the helicopter has slowed to approximately 120 KCAS. The cyclic flare must be maintained while the collective is decreased so that the rotor remains loaded during the maneuver. Without the positive load on the rotor while lowering the collective, very small cyclic movements result in very high rotor flapping angles. Maintaining the firm cyclic flare a sufficient time for the airspeed to decrease to approximately 120 KCAS resulted in rather large nose-up pitch attitudes. Figure 33 shows that from an entry speed of 181 KCAS, a cyclic flare of between 1.0 and 1.9 g was maintained for a period of 8 seconds with a pitch attitude change of 27 degrees, 15 degrees nose down to 12 degrees nose up.

55. The engine failure recognition and reaction times required of the pilot are very short. Maximum delay times for initiation of cyclic flare appear to be on the order of .5 to 1.0 second; however, this is a difficult parameter to define. The maximum collective delay is a variable depending upon the degree of cyclic flare used. Figure 33, appendix 1, shows a collective delay of 3.6 seconds with a firm cyclic flare. Two considerations favorably influence accepting these short cyclic flare time delays. First the pilot is afforded very ample warnings, audible, visual, and kinesthetic, that an engine failure has occurred. Second, at the conditions where the power failure characteristics are most objectionable, high speed and high power, a cyclic flare and decrease in airspeed is a rather natural, instinctive reaction.

56. It is considered that with proper pilot training the airspeed envelope of the helicopter need not be restricted. However, for the power failure characteristics of the AH-1G to be acceptable, proper pilot technique for engine failure recovery at high speed must be demonstrated and emphasized during transition training. Appropriate warning must be included in the operator's manual along with a discussion of recovery techniques.

SCAS-PYLON COUPLING

57. Pylon rock is the phenomenon of periodic helicopter pylon motion relative to the airframe. In its self-sustaining fully developed state the pylon rock causes the airframe to pitch and roll periodically, primarily roll, at 1/2 cyclic per rotor revolution or 2.7 cps. This pylon motion is experienced in UH-1C and UH-1D helicopters. Pylon motion in "C" and "D" models is commonly several short self-damping oscillations indicative of the state of wear of pylon dampers. A pilot's "stick rap" will generally result in a 2 to 5 cycle oscillation. The pylon rock phenomenon is a result of the "soft" pylon mounting system selected to reduce rotor vibration transmitted to the fuselage. With a "hard" pylon, rotor vibrations in the fuselage would increase but a tendency toward pylon rock would be eliminated.

58. The pylon mounting structure of the AH-1G is virtually identical to that of the UH-1C, and is subject to the same trade-off between rotor vibrations and pylon rock. The trade-off with the AH-1G is more critical for several reasons. In order to use the higher speeds of the AH-1G, the rotor vibrations must necessarily be highly isolated for the helicopter to serve as a satisfactory weapons platform. The second compounding problem is that the AH-1G incorporates

a stability and control augmentation system (SCAS). To obtain optimum handling qualities, the rate damping loop of the SCAS must respond at a required "SCAS Gain" at the same frequencies as pylon motion. That is, in order to provide near optimum handling qualities for the helicopter, particularly in the roll axis, the SCAS must respond to dampen roll rates in the same frequency range as pylon motion. This of necessity leads to a compromise in the AH-1G; Optimum handling qualities versus SCAS-coupled pylon motion.

59. When pylon rock develops in an AH-1G due to a worn or nonoptimum pylon mounting system, the pylon rock will be evidenced in the fuselage as a periodic roll rate oscillation and possibly a pitch oscillation in more strongly developed pylon rock. The only input to the rate damping loop of the SCAS is fuselage angular rate. The SCAS will sense the rate caused by pylon rock and will attempt to dampen that rate by periodic control inputs through the SCAS actuators opposing fuselage rate. Although the SCAS may be opposing fuselage rates, the periodic SCAS input may tend to aggravate the pylon rock depending upon the angular phasing of the pylon-fuselage-SCAS-control response loop. That is, perfect periodic fuselage rate damping may damp, sustain, or amplify pylon rock, depending upon these phase relationships. The SCAS gain, or magnitude of the fuselage rate damping control input resulting from a given fuselage rate, at pylon rock frequency will vary the magnitude of the pylon-SCAS coupling. Attenuated gain will reduce the coupling at the expense of optimum handling qualities.

60. To date, the trade-off between optimum handling qualities and SCAS-coupled pylon motion has been apparent. During the first Army evaluation (ref. 5), it was understood that the final tailoring or optimization of the SCAS had not been completed. The high frequency, pylon rock frequency, SCAS gain was attenuated to avoid the possibility of SCAS-coupled pylon rock. Later, a short follow-on evaluation, letter report, Aug 67 (Cobra Reevaluation, ref. 6) was conducted. The same aircraft following SCAS optimization showed excellent lateral handling qualities. During the reevaluation, a condition of SCAS reinforced divergent 1/2 per rev oscillation resulted in a precautionary landing, and test termination. The following recommendation was made in the subject reevaluation: "Considering the structural implications of this type of motion, production aircraft must incorporate design protection

that will prevent pylon-SCAS coupling." This reevaluation fixed the SCAS configuration for handling qualities; however, no adequate design protection against SCAS-pylon coupling was provided.

61. SCAS-pylon coupling was observed in varying degrees in at least three of the four Hueycobras which were adequately instrumented to detect the malfunction. The corrective measures to date have consisted of replacing dampers when there was evidence of wear, and of attenuating the high frequency gain of the rate damping loop of the SCAS to the optimum level of that particular stage of wear. During the USAAVNTA Phase B tests on Hueycobra #2 (USA S/N 615246), pylon motion became objectionable. The condition was self-excited and neutrally damped. The "production" viscous dampers were worn and were replaced. The pylon rock condition was improved but still present. The rate damping gain of the SCAS roll axis was then attenuated through replacing one resistor and one capacitor. This change eliminated the self-sustaining pylon rock. The oscillation would dampen when excited by a gust or stick rap. Following this change, however, the roll oscillation described in paragraph 36 became objectionable. Figure 19, appendix I, shows this oscillation following SCAS attenuation.

62. Both before and after the corrective measures, small periodic longitudinal cyclic control inputs were observed on the instrumentation records. These inadvertant pilot induced oscillations (PIO) were at pylon rock frequency. This small P.I.O. was observed during flights by a qualified engineering test pilot conscious of the problem and attempting to avoid it. Inadvertant P.I.O. was a result of the pylon rock problem, and not the cause. The periodic motion of the helicopter around the pilot caused him to "close the loop" with longitudinal control input. At the time the P.I.O. was observed, cyclic friction was moderate (greater friction than the pilot preferred, and greater than that recommended by the contractor). Any recommendation by the contractor to fly with increased cyclic friction may, under some circumstances, tend to mask the basic problem at the expense of the pilot's preference in control "feel". Pilot preference in control "feel" assumes added significance in mission performance for this helicopter where fixed armament subsystems must be aimed by helicopter attitude.

63. To reduce the SCAS-pylon coupling effect and to ensure optimum flying qualities for the AH-1G during service use, two conditions must be met. (1) An optimum pylon mounting system must by achieved. (2) Final tailoring of the SCAS gain, especially in the roll axis, must be determined prior to the helicopter's being delivered for operational use.

SCAS-OFF QUALITATIVE EVALUATION

64. Throughout the conduct of the Phase B test, at each configuration flown the SCAS was periodically turned off. Although the SCAS-off handling qualities deteriorated drastically, the helicopter could be flown throughout its flight envelope. No limitation of the flight envelope with the SCAS inoperative is recommended. Mission continuation/abort decisions in the event of SCAS failure must be based on situation; however, with SCAS inoperative the AH-1G stability and controllability characteristics are markedly degraded. Suitability as a weapons platform is greatly reduced.

65. The roll oscillation described in paragraph 36 became very objectionable without SCAS damping. The accuracy of attitude aimed wing stores is questionable primarily due to this characteristic. Roll response deteriorated without SCAS so that precise heading changes were difficult to make rapidly, with a tendency toward overcontrolling. Longitudinal maneuvering characteristics deteriorated so that accurate control of load factor demanded undue pilot attention. The degree to which the SCAS-off handling qualities of the helicopter are objectionable is dependent upon air turbulence. In moderate turbulence the effectiveness of the helicopter SCAS off, as a weapons platform is doubtful.

VIBRATION SURVEY

66. Tests were conducted to determine the vibration characteristics of the test helicopter and to check compliance with deviation 1, page 95, ref 4. Although the required data has been collected, they have not yet been reduced or analyzed. Prior to beginning of Phase B testing, it was discovered that adequate calibration of the vibration instrumentation was not possible on available calibration equipment. Rather than delay the conduct of this test, the vibration instrumentation was installed on the test aircraft. The same instrumentation will be used for later Phase B tests and will be calibrated after Phase B testing has been completed. At that time an amendment to this report will be published.

NOISE LEVEL SURVEY

67. A noise level survey was conducted on the test helicopter to measure sound levels near the crew stations. One flight was conducted in conjunction with the vibration survey in the alternate configuration. Noise levels at both crew members' heads were recorded at airspeeds between Hover

and V_{ne}. No tests were conducted during firing or other configurations due to nonavailability of sound measuring equipment. The test results are presented in figure 37, appendix I. Qualitatively, cockpit noise levels were not considered objectionable at either crew member's station.

SYNCHRONIZED ELEVATOR MOVEMENT

68. During the contractor jettison tests, an on-board tail camera revealed considerable movement or flutter of the synchronized elevator. Instrumentation was installed to determine the nature of this movement. Figure 38, appendix I, shows the measured magnitude of the elevator movement. No adjustments of the elevator by the contractor were noted during the test program. The test results indicate that the oscillatory elevator movement was primarily at a frequency of 2 cycles per rotor revolution (10.8 cps) with amplitude increasing with airspeed. No other correlation could be found. The magnitude of the oscillation was characterized by a high degree of scatter, but the magnitude of the oscillation did not appear to vary consistently with gross weight, C. G., or helicopter external configuration. No increase in magnitude was noted with time; however, this movement may possibly result in future structural problems and should be eliminated.

CYCLIC CONTROL SYSTEM STATIC FORCES

69. The cyclic control system static forces were measured with a hand-held force gage as a function of stick displacement. The results are shown in figures 39 through 42, appendix I. The lateral cyclic static imbalance noted in reference 5 was still present. In order to maintain coordinated flight, a constant right lateral force was required. This lateral force could not easily be trimmed and was disconcerting. The contractor attempted to correct this problem by installing a balancing spring in the control system; however, this change was not satisfactory. The static imbalance was particularly annoying when flying from the front seat. The location of the sidearm cyclic was such that the steady right force had to be exerted by the extended forearm. This force proved to be fatiguing to the copilot after a short period of time. Static lateral control force balance is required to improve the operational suitability of the helicopter.

Conclusions

70. The following conclusions were reached at the completion of Part 1 of the AH-1G Phase B test:

a. SCAS-pylon coupling is a continuing problem of the AH-1G with possible structural implications (para 57 through 63).

b. The flight characteristics of the AH-1G after power failure required positive corrective action by the pilot. A short recognition and reaction time delay was available for these corrective actions (para 54).

c. Without the SCAS, flight throughout the flight envelope was possible, but the effectiveness of the helicopter as a weapons platform was greatly reduced (para 64 and 65).

d. The reaction of the helicopter to weapons firing was not objectionable (para 52).

e. Directional control power was inadequate at some conditions within the flight envelope of the helicopter (para 42 and 43).

f. Undue pilot attention was required to avoid exceeding the torque limits of the helicopter transmission (para 47 and 48).

g. The cyclic control system has a lateral force imbalance which requires that the pilot maintain a constant right force on the cyclic (para 23 and 69).

h. The pilot's armament control system was inadequate and illogical (para 14).

i. Higher static longitudinal cyclic position gradients at high speed would improve the mission suitability of the aircraft (para 29).

j. The airspeed position error as used by the contractor is in error, particularly at airspeeds greater than 160 KIAS. The actual calibrated airspeed at 180 KIAS is 174 KCAS rather than 180 KCAS as claimed. This error should have little effect upon the service use of the helicopter (para 26 and 27).

k. The fuel control emergency switch in the copilot/ gunner's cockpit was not sufficiently protected (para 19).

l. The rotor speed selector (beep) switch in the copilot/ gunner's cockpit cannot be reached while changing collective pitch (para 20).

m. The cockpit ventilation system was only marginally adequate (para 24).

n. The canopy hold-open mechanism for both cockpits was inadequate (para 10).

o. The pilot's master caution panel was located so that direct sunlight made identification of the nature of a warning difficult (para 11).

p. Visual inspection of the oil level in the tail rotor gearbox was not possible because the sight gage was not transparent (para 7).

q. Helmet hooks were required in both the pilot's and copilot/gunner's cockpits (para 8 and 18).

Recommendations

71. The following recommendations are made to improve the AH-1G helicopter for operational use:

a. Adequate design protection should be provided to preclude SCAS-pylon coupling (para 63).

b. Power failure characteristics must be emphasized and demonstrated during pilot transition training. Appropriate warning and explanation of recovery technique must be entered in the operator's manual (para 56).

c. The flight envelope of the helicopter should not be restricted following a SCAS failure (para 64).

d. The flight envelope for weapons firing should not be restricted due to handling qualities considerations (para 52).

e. Additional testing should be conducted to determine adequacy of directional control power (para 43).

f. Automatic torque limiting should be provided in order to avoid exceeding the torque limit of the main transmission (para 47 and 48).

g. Static balance should be provided for the lateral cyclic control system (para 69).

h. The pilot's armament control system should be redesigned (para 14).

i. Static longitudinal cyclic position gradients should be increased at high speeds (para 29).

j. The contractor's airworthiness qualification reports should be modified to reflect the changes required as a result of the airspeed position error discrepancy (para 26).

k. The fuel control emergency switch in the copilot/gunner's cockpit should be adequately guarded (para 19).

l. The rotor speed select (beep) switch in the copilot/gunner's cockpit should be relocated to the collective pitch control (para 20).

m. The cockpit ventilation system should be improved (para 24).

n. The canopy hold-open mechanism should be improved (para 10).

o. The pilot's master caution panel should be relocated or shielded from direct sunlight (para 11).

p. A transparent inspection port should be provided for the tail rotor gearbox (para 7).

q. Helmet hooks should be provided in all AH-1G aircraft (para 8 and 18).

APPENDIX I

TEST DATA

Figure No. 1
Airspeed Calibration
AH-1G USA S/N 615246

Gross Weight	CG Station	Density Altitude	Rotor Speed	Configuration
8280 LBS.	193.3 IN.	5360 FT.	324 RPM	BASIC (AIRSPEED BOOM REMOVED)

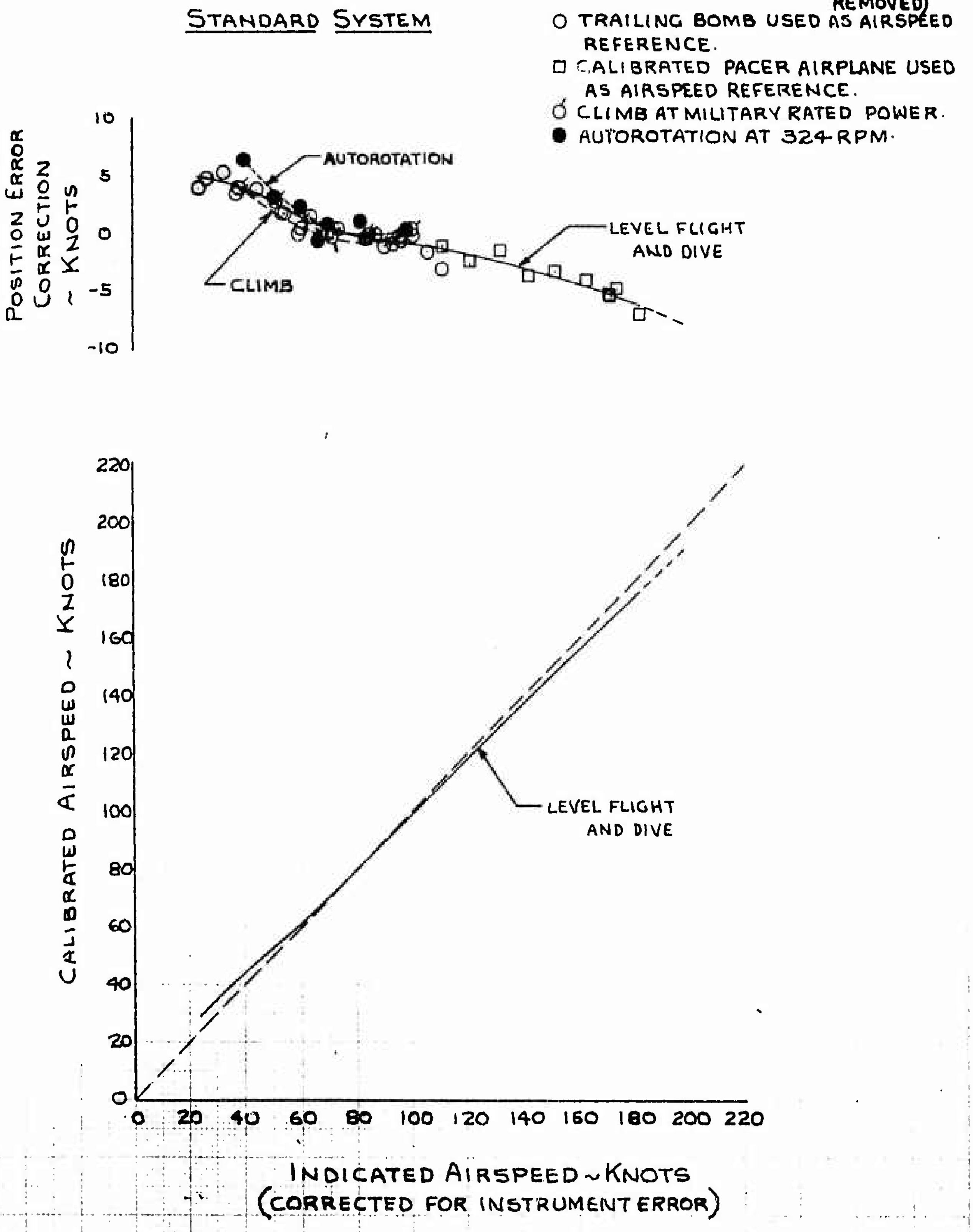


FIGURE NO. 2

AIRSPEED CALIBRATION

AH-1G USA S/N 615246

GROSS WEIGHT	C.G. STATION	DENSITY ALTITUDE	ROTOR SPEED	CONFIGURATION
8160 LBS.	193.2 IN.	6200 FT.	324 RPM	BASIC

BOOM SYSTEM

NOTES: 1. FLAGGED SYMBOLS DENOTE CLIMB AT MILITARY RATED POWER.
2. SHADED SYMBOLS DENOTE AUTOROTATION
3. SQUARE (□) SYMBOLS DENOTE CALIBRATED PACER USED AS AIRSPEED REFERENCE.
4. ROUND (○) SYMBOLS DENOTE TRAILING BOMB USED AS AIRSPEED REFERENCE.

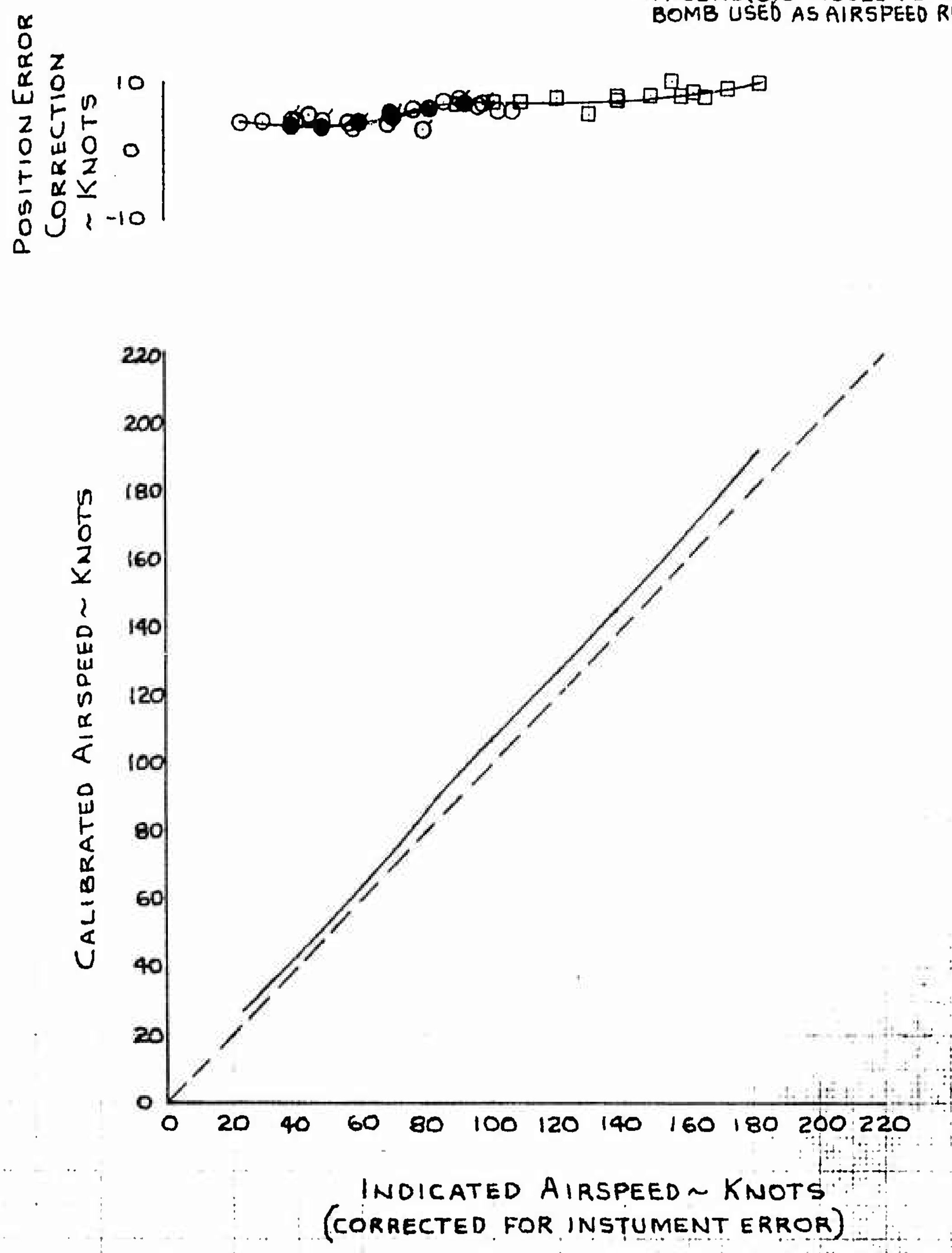


FIGURE NO. 3

STATIC LONGITUDINAL STABILITY

AH-1G USA S/N 615246

GROSS WEIGHT	C.G. STATION	DENSITY ALTITUDE	ROTOR SPEED	CONFIGURATION
9230 LBS.	194.7 IN.	5760 FT.	324 RPM	HOG

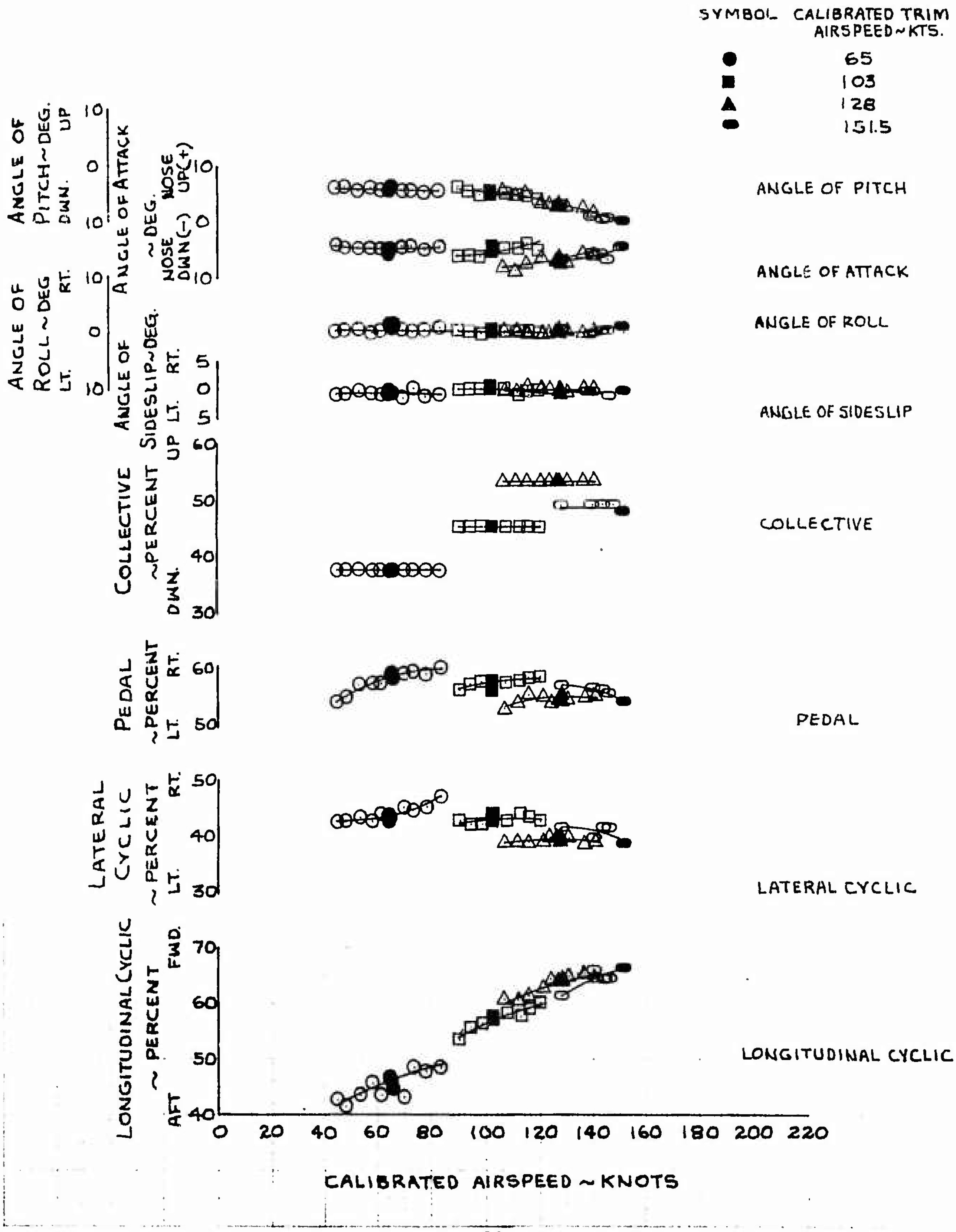


FIGURE NO. 4

STATIC LONGITUDINAL STABILITY

AH-1G USA S/N 615246

GROSS WEIGHT	C.G. STATION	DENSITY ALTITUDE	ROTOR SPEED	CONFIGURATION
8660 LBS.	194.2 IN.	5480 FT.	324 RPM	SCOUT

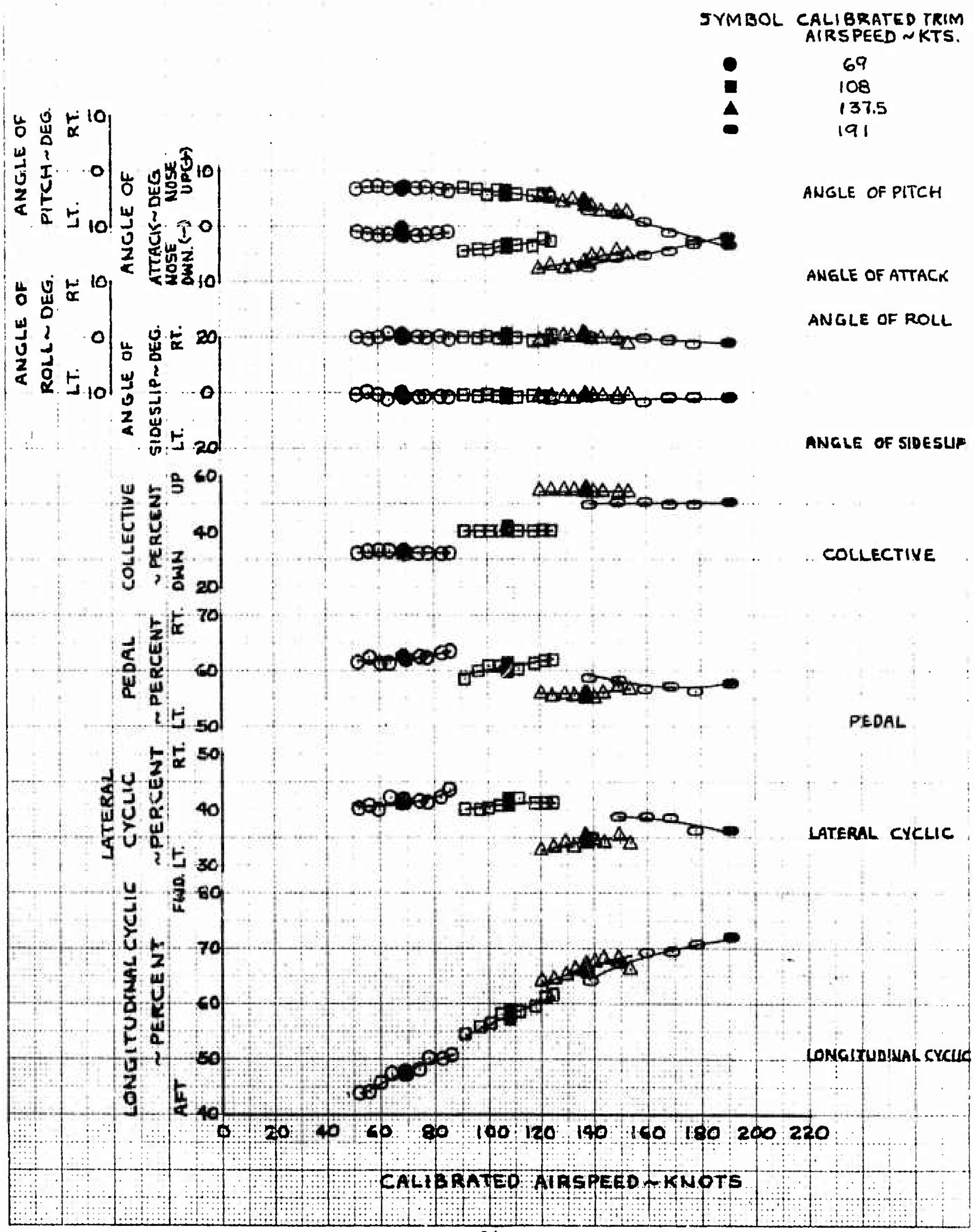


FIGURE NO. 5
STATIC LONGITUDINAL STABILITY
AH-1G USA S/N 615246

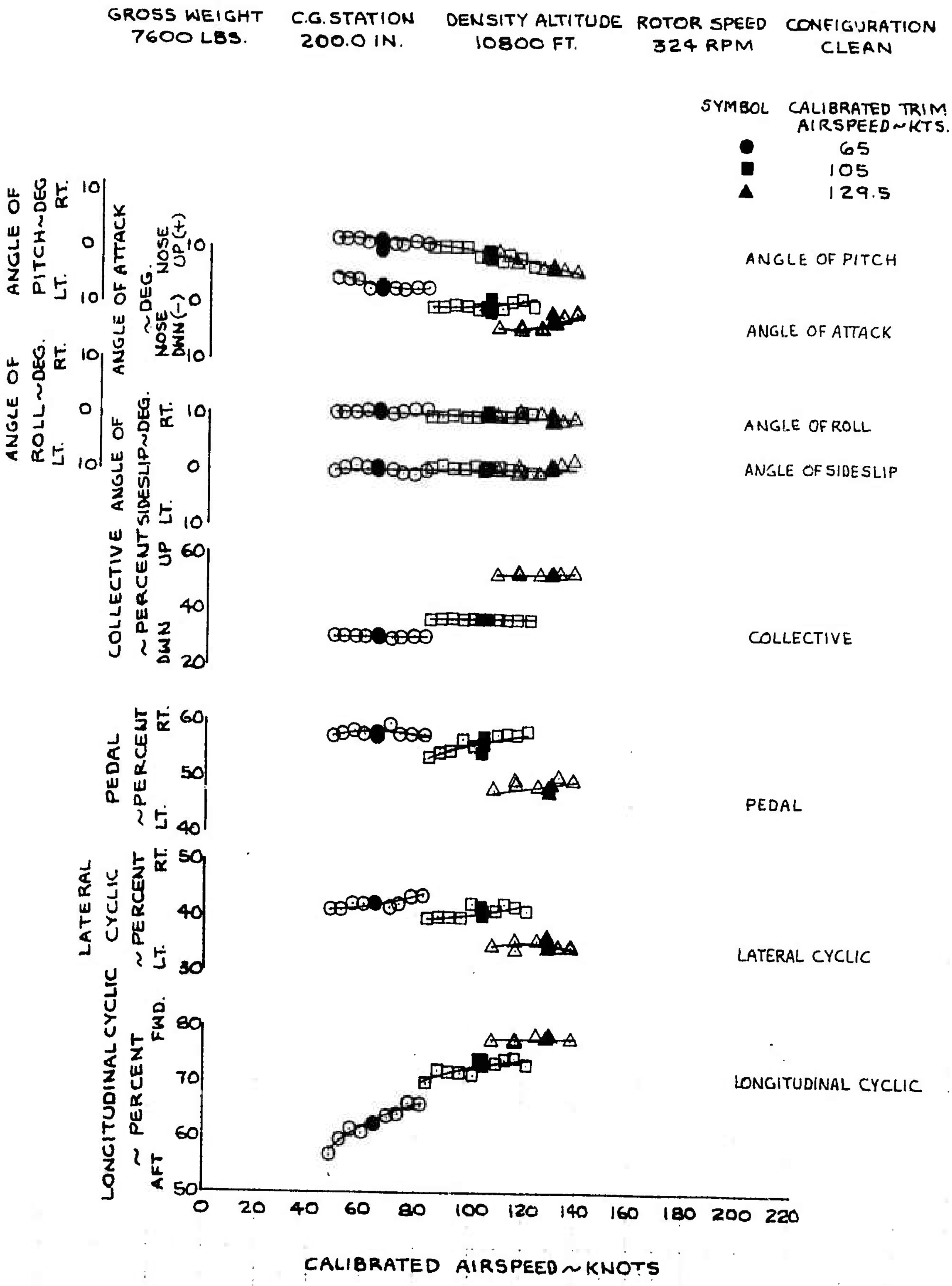


FIGURE NO. 6

STATIC LATERAL DIRECTIONAL STABILITY

AH-1G USA S/N 615246

65 KNOTS CALIBRATED AIRSPEED

GROSS WEIGHT ~LBS	C.G. STATION ~IN.	DENSITY ALT. ~FT.	ROTOR SPEED ~RPM	CONFIGURATION
8980	194.2	4840	324	HOG

NOTE: SHADED SYMBOLS DENOTE TRIM

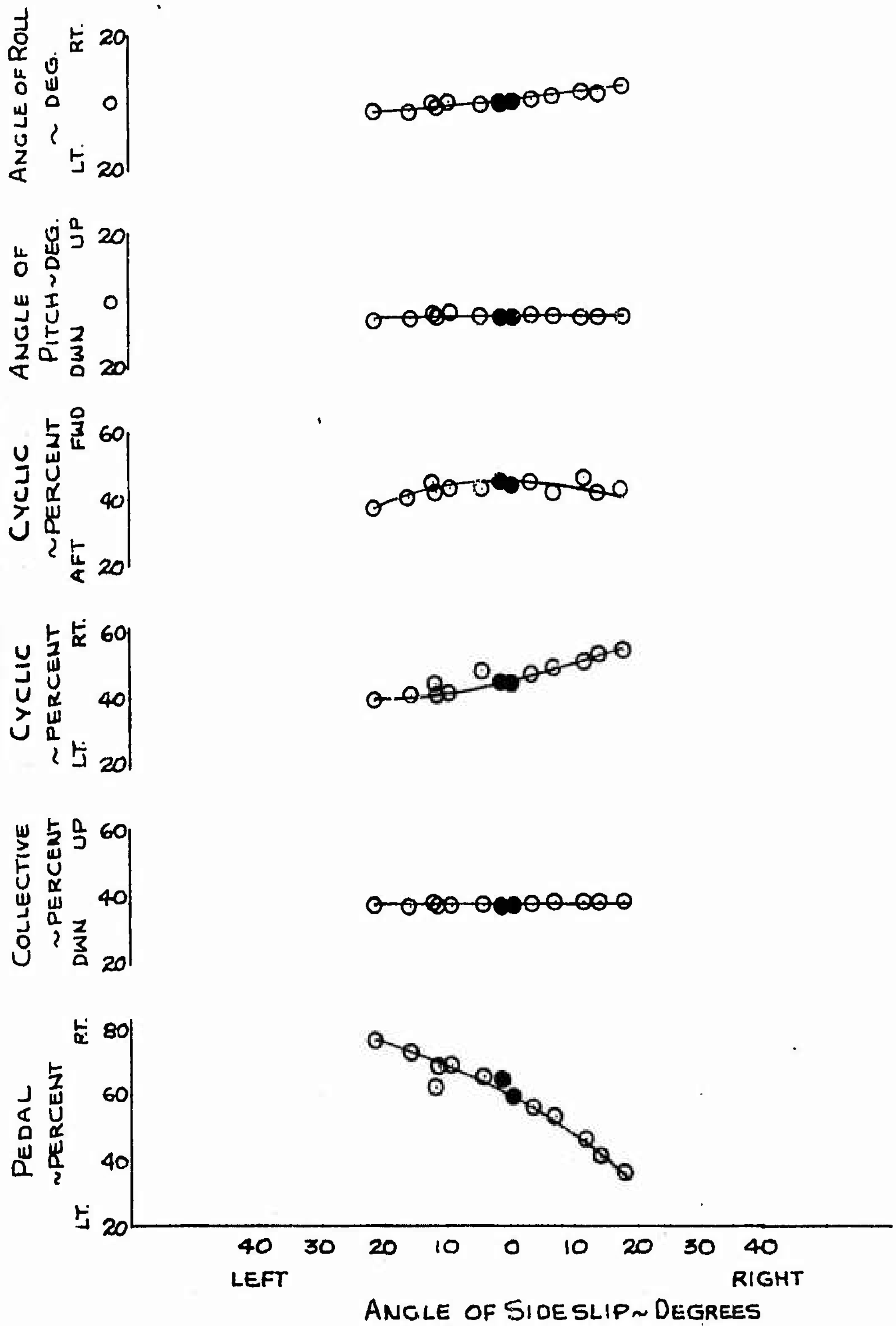


FIGURE NO. 7

STATIC LATERAL DIRECTIONAL STABILITY

AH-1G USA S/N 615246

102 KNOTS CALIBRATED AIRSPEED

GROSS WEIGHT ~LBS	C.G. STATION ~IN.	DENSITY ALT. ~FT.	ROTOR SPEED ~RPM	CONFIGURATION
8810	194.2	4890	324	HOG

NOTE: SHADED SYMBOLS DENOTE TRIM

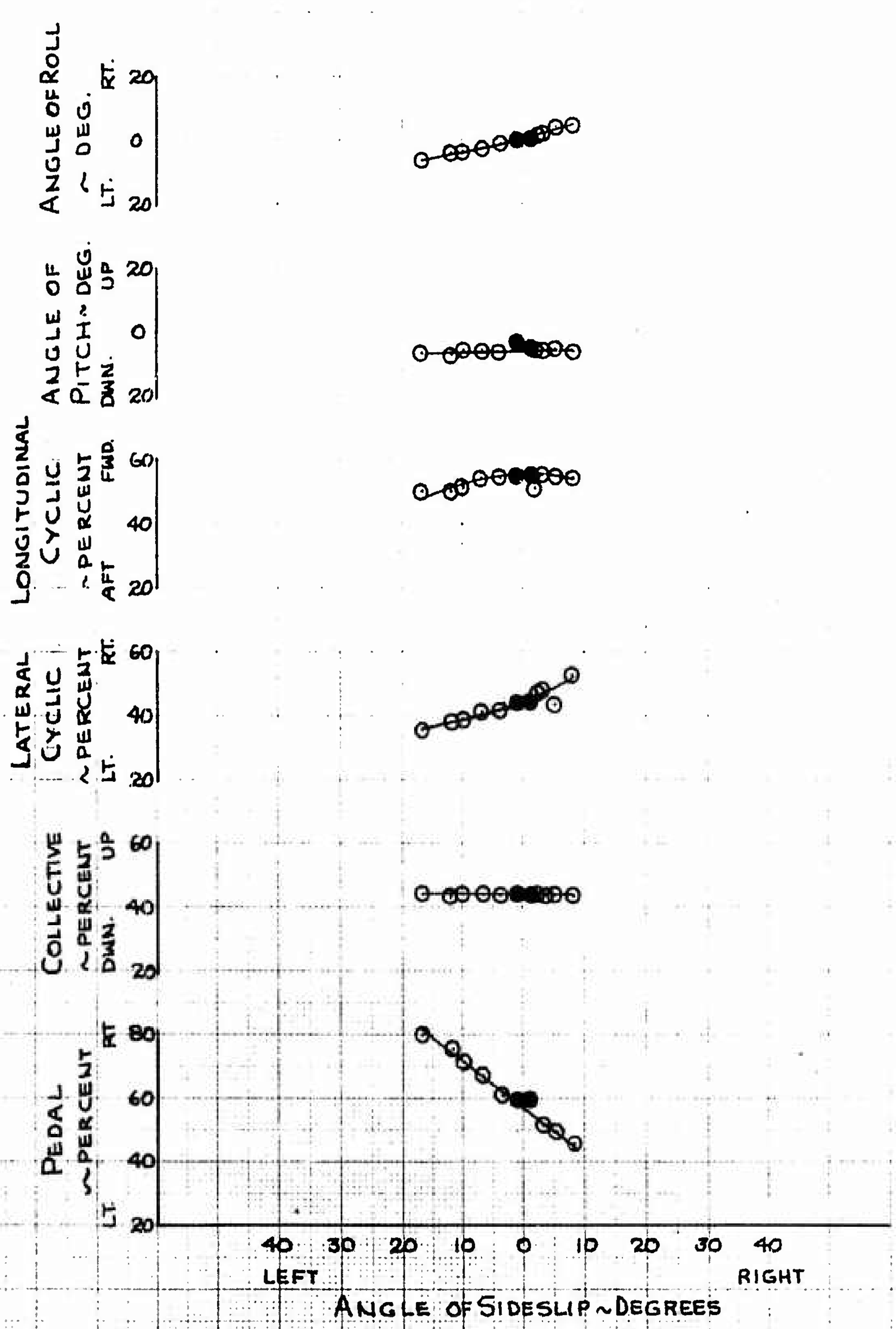


FIGURE No. 8

STATIC LATERAL DIRECTIONAL STABILITY

AH-1G USA S/N 615246

126 KNOTS CALIBRATED AIRSPEED

GROSS WEIGHT ~LBS	C.G. STATION ~IN.	DENSITY ALT. ~FT.	ROTOR SPEED ~RPM	CONFIGURATION
9250	194.5	5520	324	HOG

NOTE: SHADED SYMBOLS DENOTE TRIM

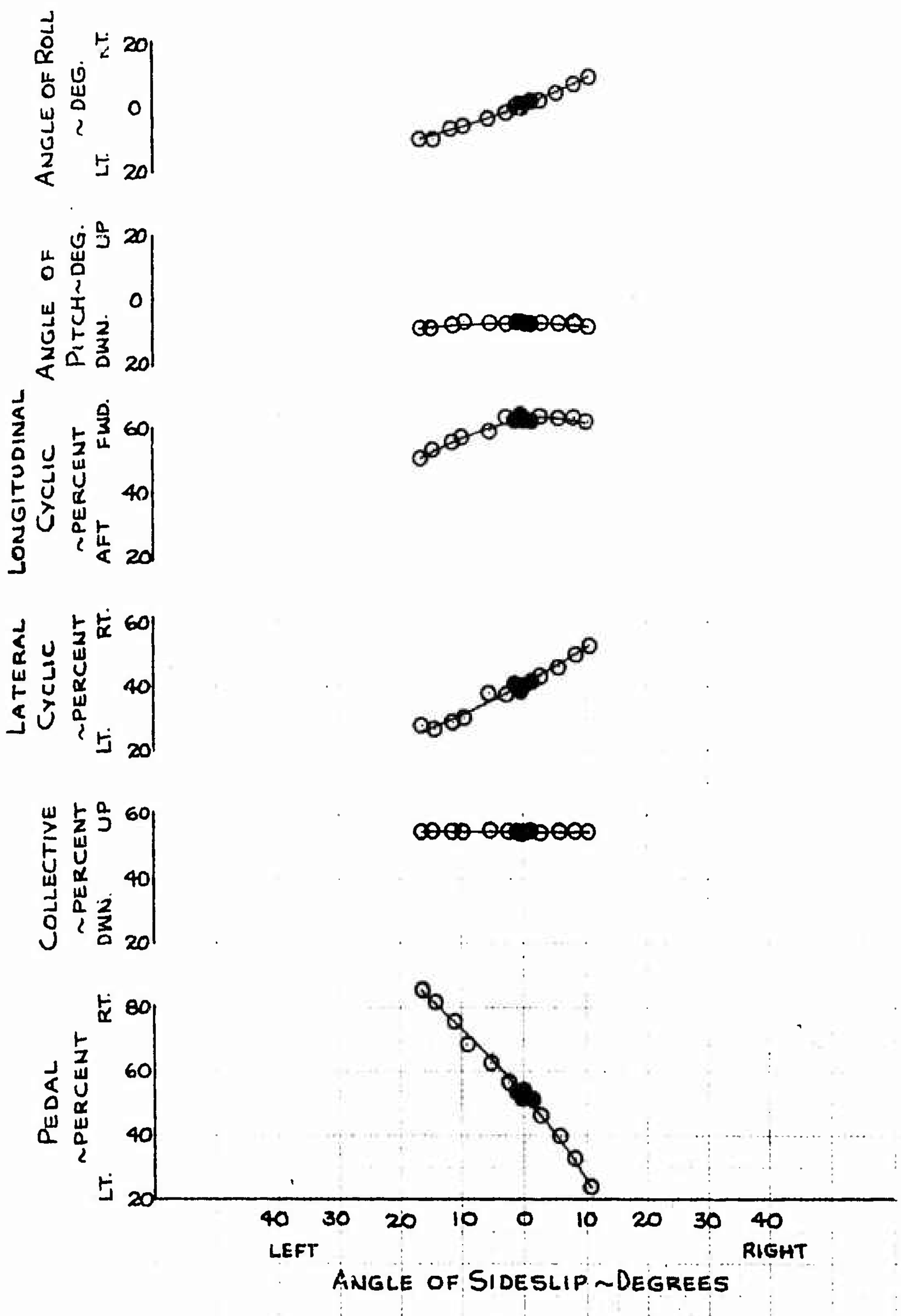


FIGURE NO. 9

STATIC LATERAL DIRECTIONAL STABILITY

AH-1G USA S/N 615246

166.5 KNOTS CALIBRATED AIRSPEED

GROSS WEIGHT ~LBS	C.G. STATION ~IN.	DENSITY ALT. ~FT.	ROTOR SPEED ~RPM	CONFIGURATION
8920	194.2	6100	324	HOG

NOTE: SHADED SYMBOLS DENOTE TRIM

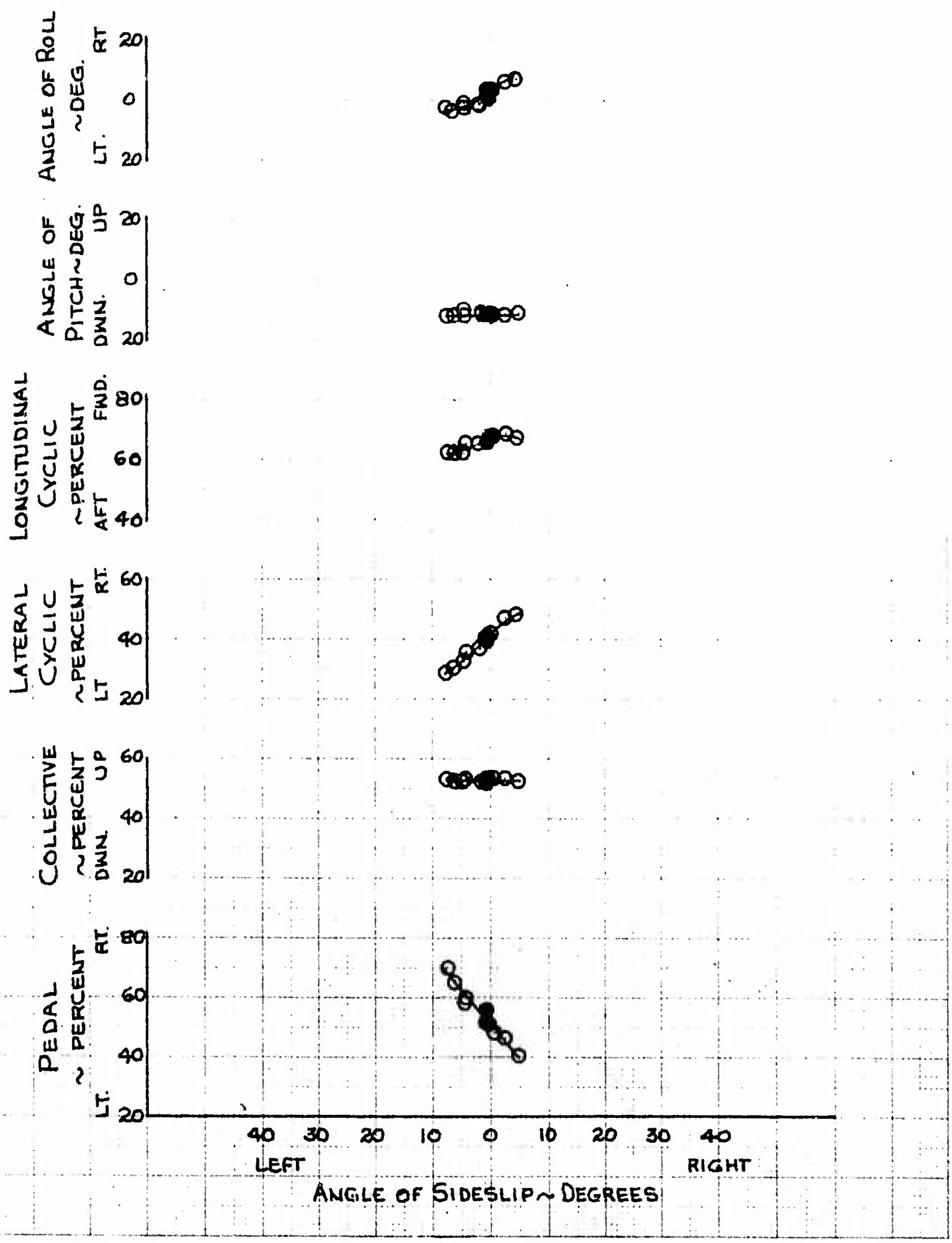
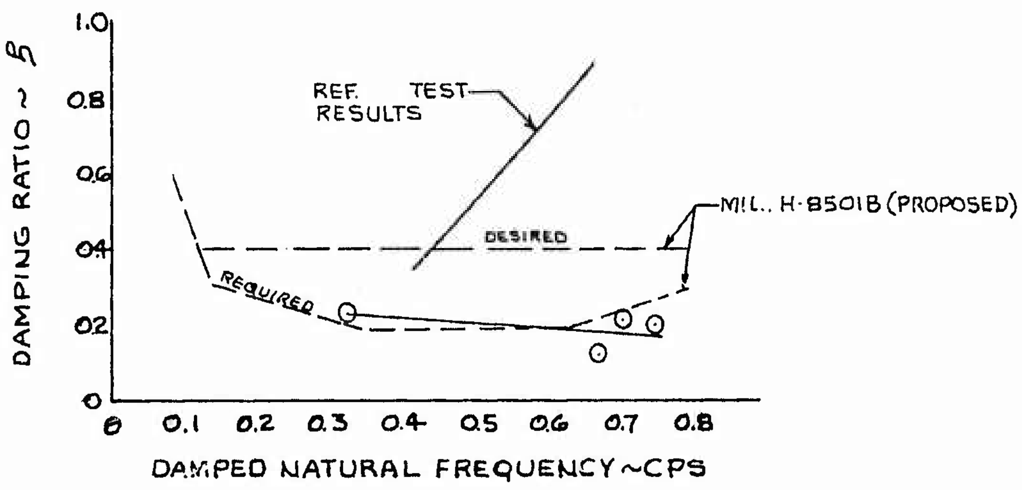


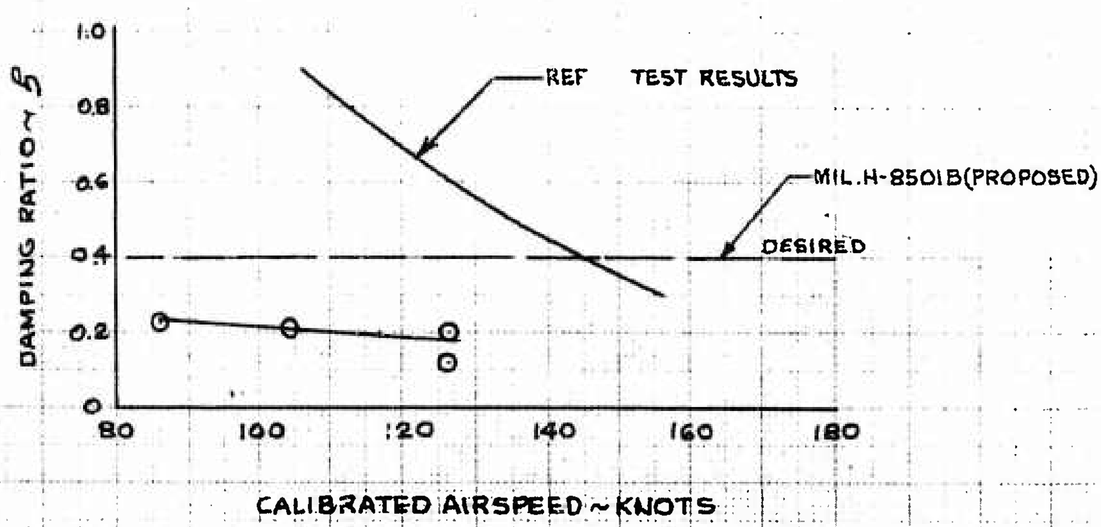
Figure No. 10

Lateral-Directional Dynamic Stability

AH-1G USA S/N 615246

Gross Weight ~LBS	C.G. Station ~IN.	Density Altitude ~FT.	Rotor Speed ~RPM	Configuration
8740	194.4	7740	324	HOG





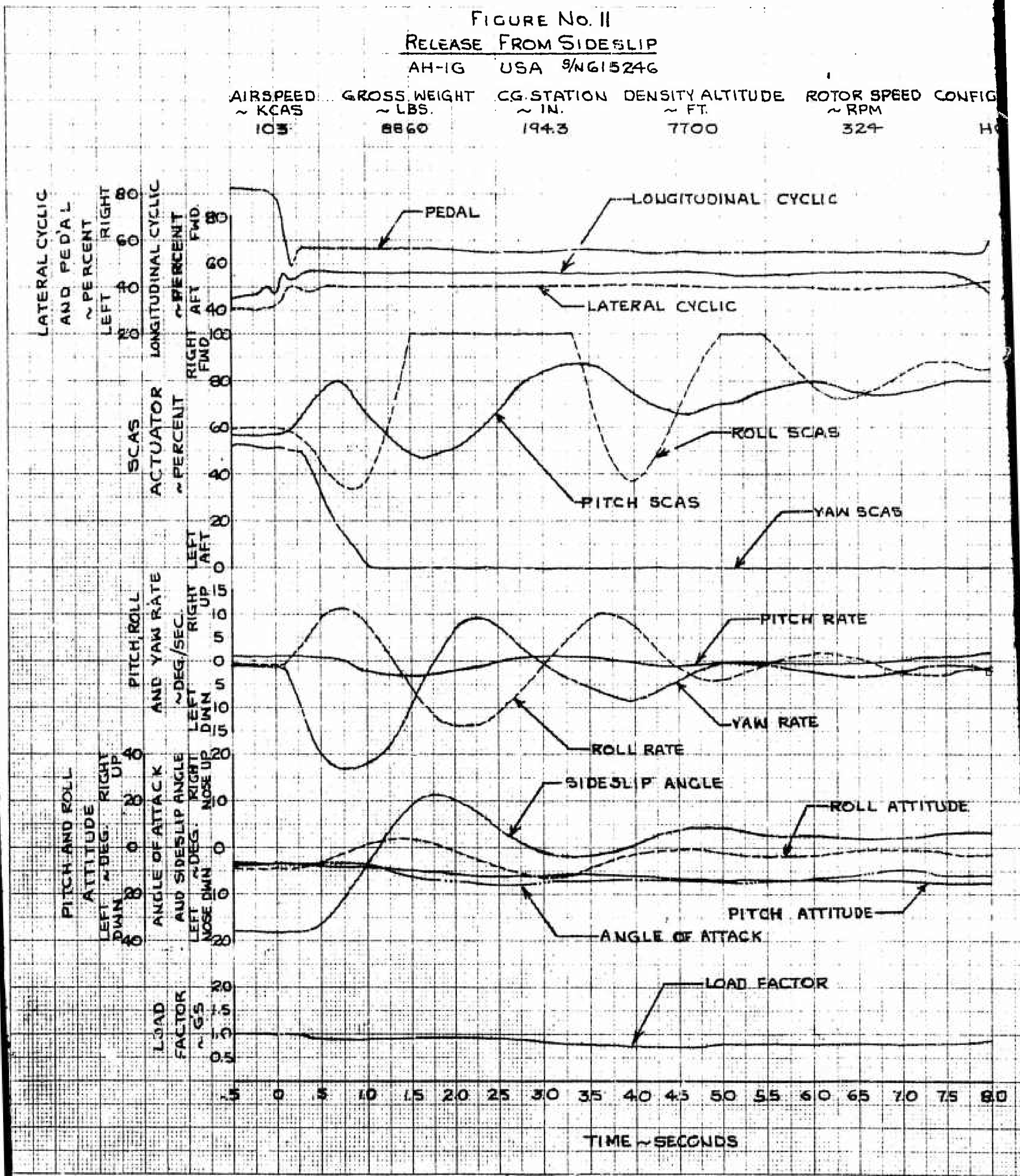
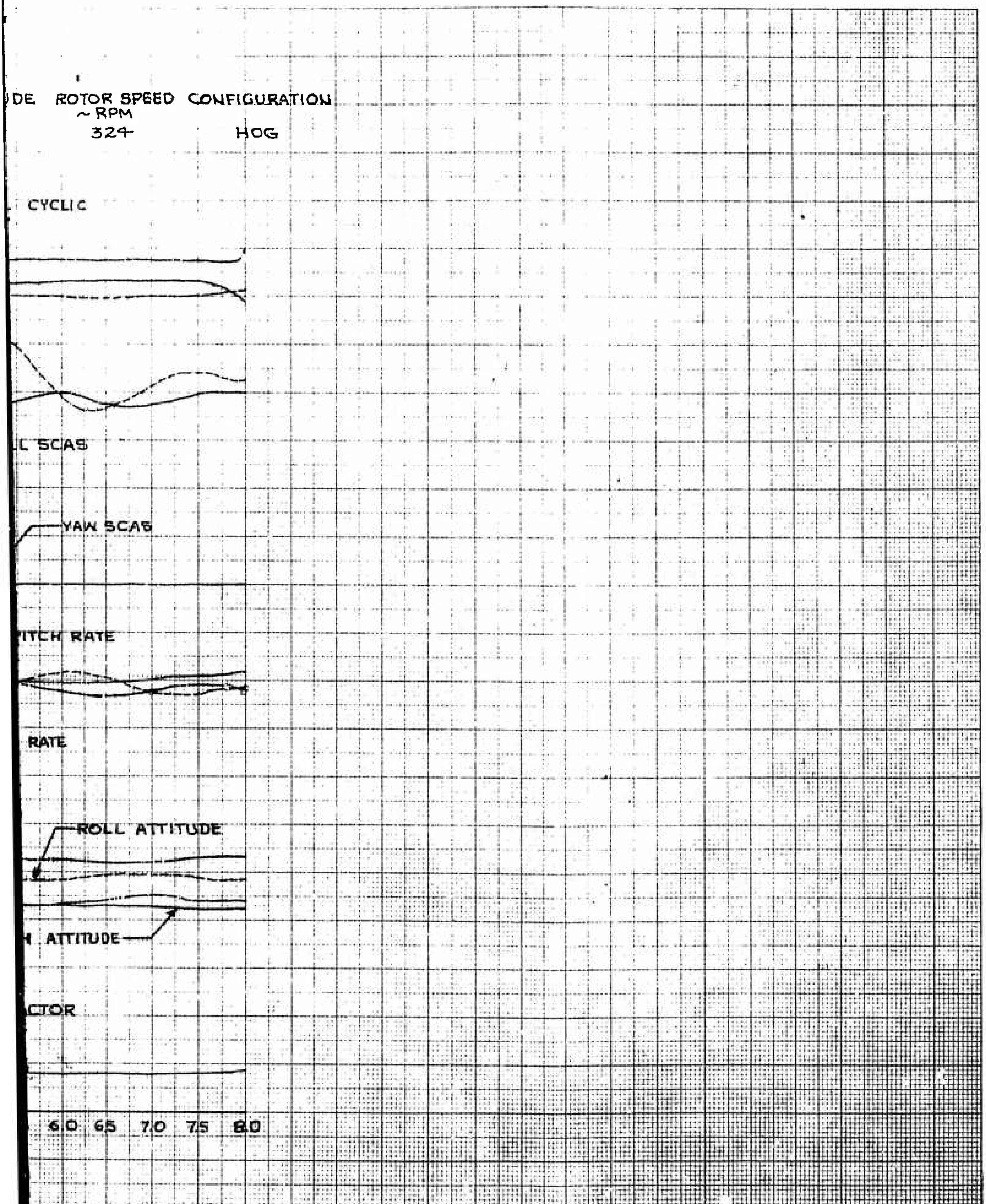


FIGURE No. 11
RELEASE FROM SIDESLIP
AH-1G USA S/N 615246
AIRSPEED ~ KCAS 103
GROSS WEIGHT ~ LBS. 8860
C.G. STATION ~ IN. 194.3
DENSITY ALTITUDE ~ FT. 7700
ROTOR SPEED ~ RPM 324
CONFIG
LATERAL CYCLIC AND PEDAL ~ PERCENT
LEFT RIGHT
LONGITUDINAL CYCLIC ~ PERCENT
AFT FWD.
PEDAL
LONGITUDINAL CYCLIC
LATERAL CYCLIC
SCAS ACTUATOR ~ PERCENT
RIGHT FWD.
LEFT AFT
ROLL SCAS
PITCH SCAS
YAW SCAS
PITCH, ROLL AND YAW RATE ~ DEG./SEC.
RIGHT UP
LEFT DWN
PITCH RATE
YAW RATE
ROLL RATE
PITCH AND ROLL ATTITUDE ~ DEG.
ANGLE OF ATTACK AND SIDESLIP ANGLE ~ DEG.
RIGHT NOSE UP
LEFT NOSE DWN
SIDESLIP ANGLE
ROLL ATTITUDE
PITCH ATTITUDE
ANGLE OF ATTACK
LOAD FACTOR ~ G'S
LOAD FACTOR
TIME ~ SECONDS



DE ROTOR SPEED ~ RPM CONFIGURATION
324 HOG
CYCLIC
L SCAS
YAW SCAS
ITCH RATE
RATE
ROLL ATTITUDE
H ATTITUDE
CTOR
6.0 6.5 7.0 7.5 8.0

2

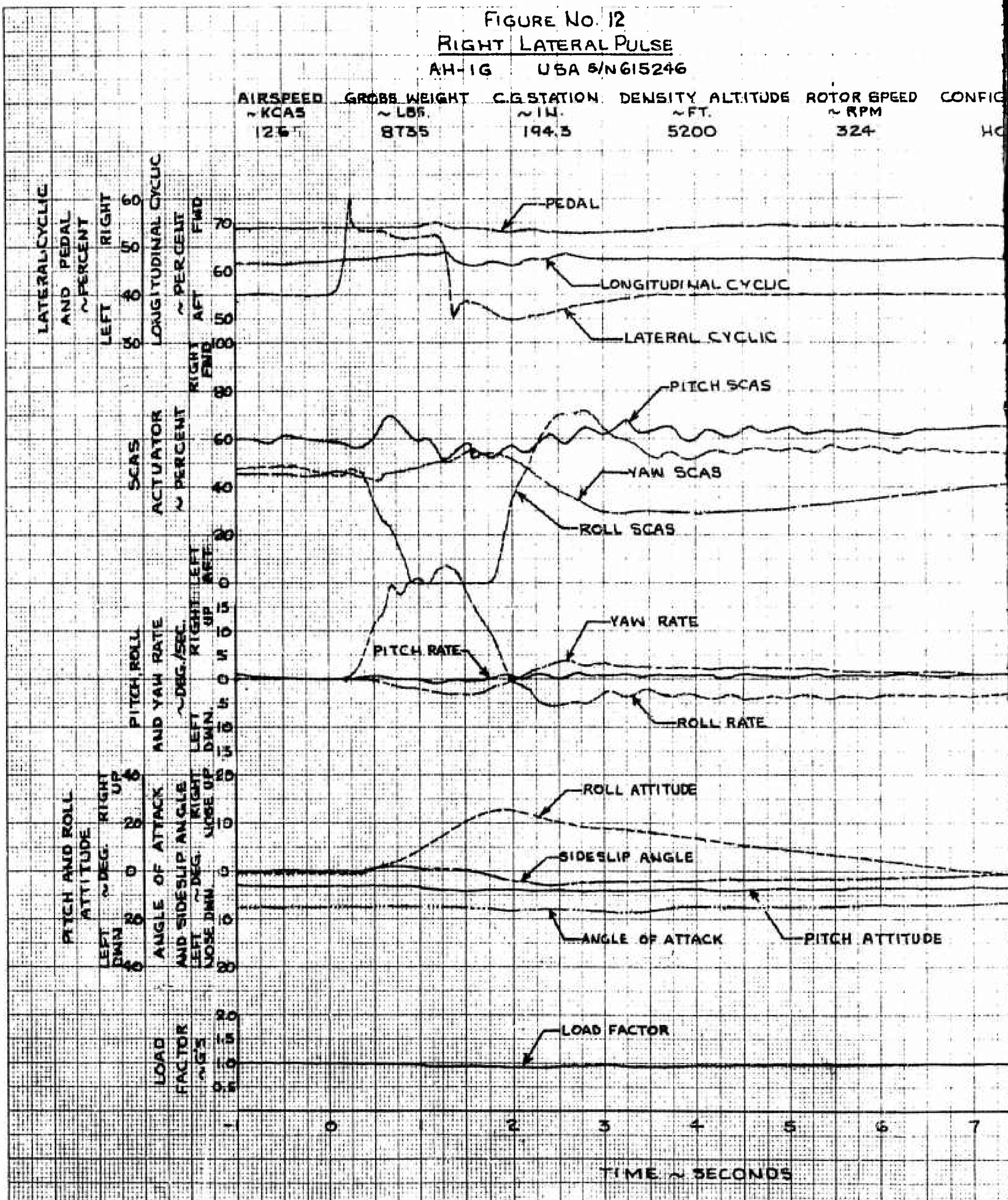
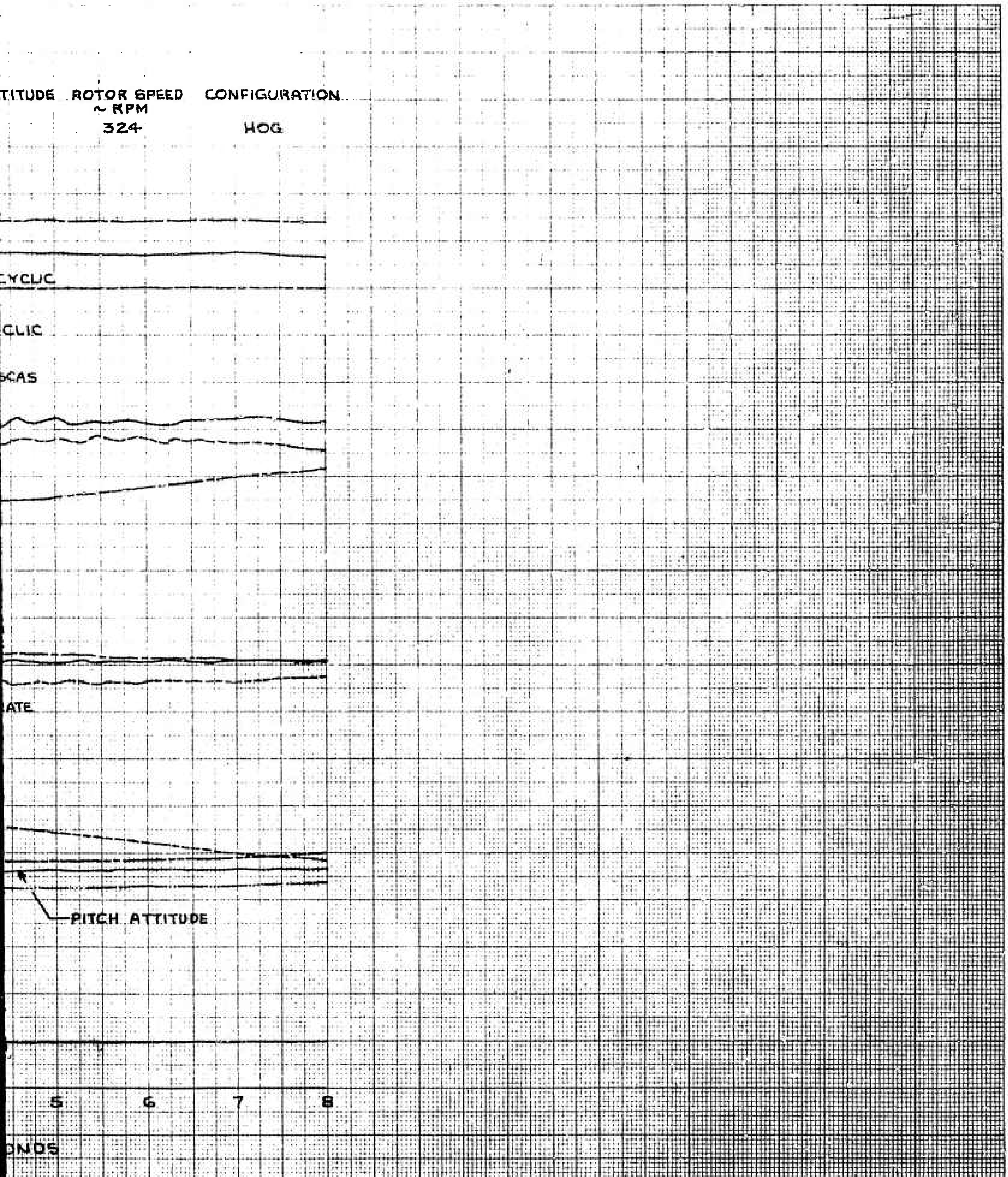


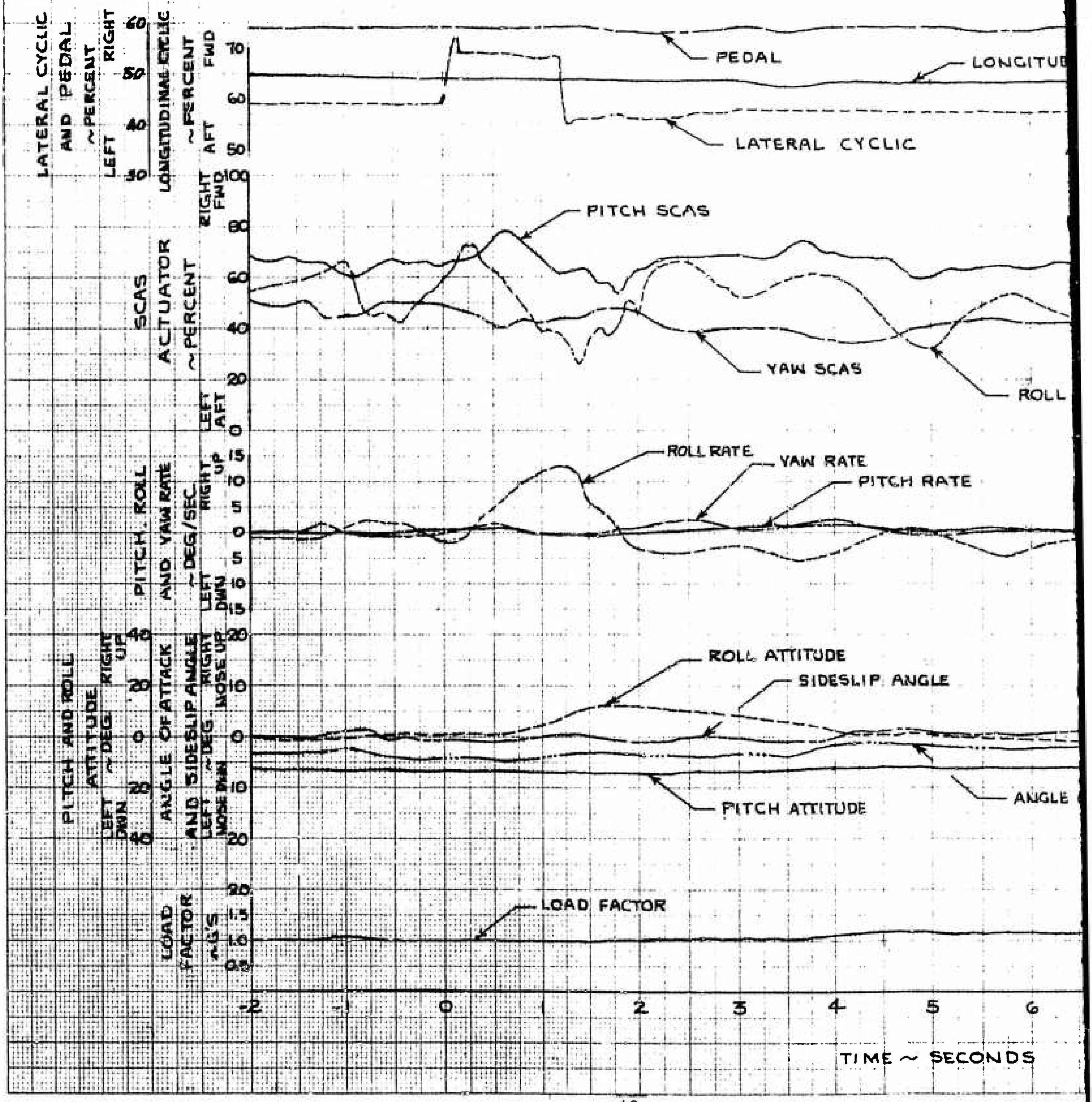
FIGURE NO. 12
RIGHT LATERAL PULSE
AH-1G USA S/N 615246
AIRSPEED ~KCAS
GROSS WEIGHT ~LBS. 8735
C.G. STATION ~IN. 194.3
DENSITY ALTITUDE ~FT. 5200
ROTOR SPEED ~RPM 324
PEDAL
LONGITUDINAL CYCLIC
LATERAL CYCLIC
PITCH SCAS
YAW SCAS
ROLL SCAS
YAW RATE
PITCH RATE
ROLL RATE
ROLL ATTITUDE
SIDESLIP ANGLE
ANGLE OF ATTACK
PITCH ATTITUDE
LOAD FACTOR
LATERAL CYCLIC AND PEDAL ~PERCENT
LONGITUDINAL CYCLIC ~PERCENT
SCAS ACTUATOR ~PERCENT
PITCH, ROLL AND YAW RATE ~DEG./SEC.
PITCH AND ROLL ATTITUDE ~DEG.
ANGLE OF ATTACK AND SIDESLIP ANGLE ~DEG.
LOAD FACTOR ~G'S
TIME ~ SECONDS

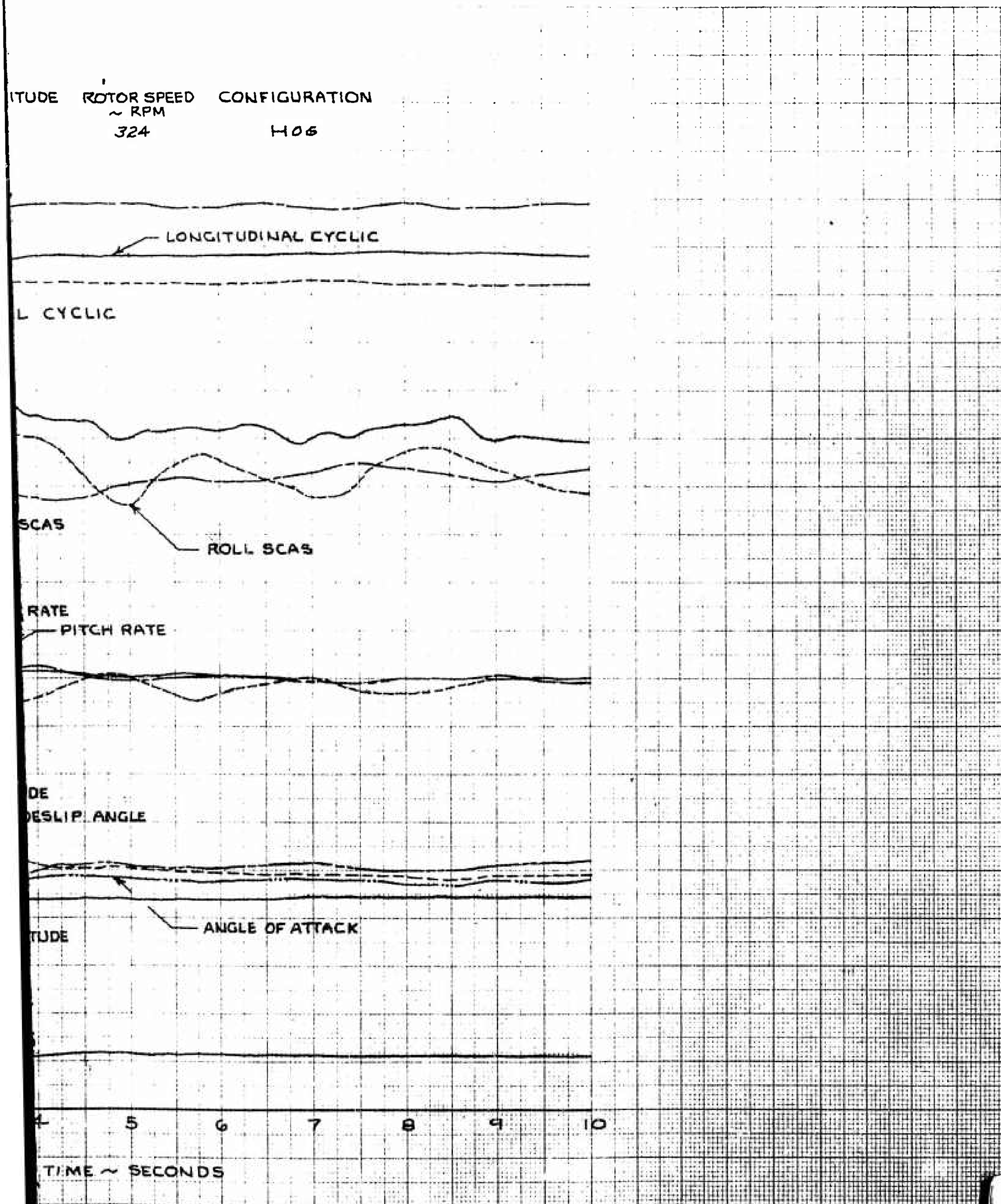


TITUDE
ROTOR SPEED ~ RPM
324
CONFIGURATION
HOG
CYCLIC
CLIC
SCAS
ATE
PITCH ATTITUDE
5
6
7
8
ONDS

FIGURE No. 13
RIGHT LATERAL PULSE
AH-1G USA S/N 615246

AIRSPEED ~KCAS	GROSS WEIGHT ~LBS.	C.G. STATION ~IN.	DENSITY ALTITUDE ~FT.	ROTOR SPEED ~RPM	CO
191	8910	194.5	3200	324	





ITUDE
ROTOR SPEED ~ RPM
324
CONFIGURATION
H06
LONGITUDINAL CYCLIC
L CYCLIC
SCAS
ROLL SCAS
RATE
PITCH RATE
DE
DESLIP ANGLE
ANGLE OF ATTACK
TUDE
4
5
6
7
8
9
10
TIME ~ SECONDS

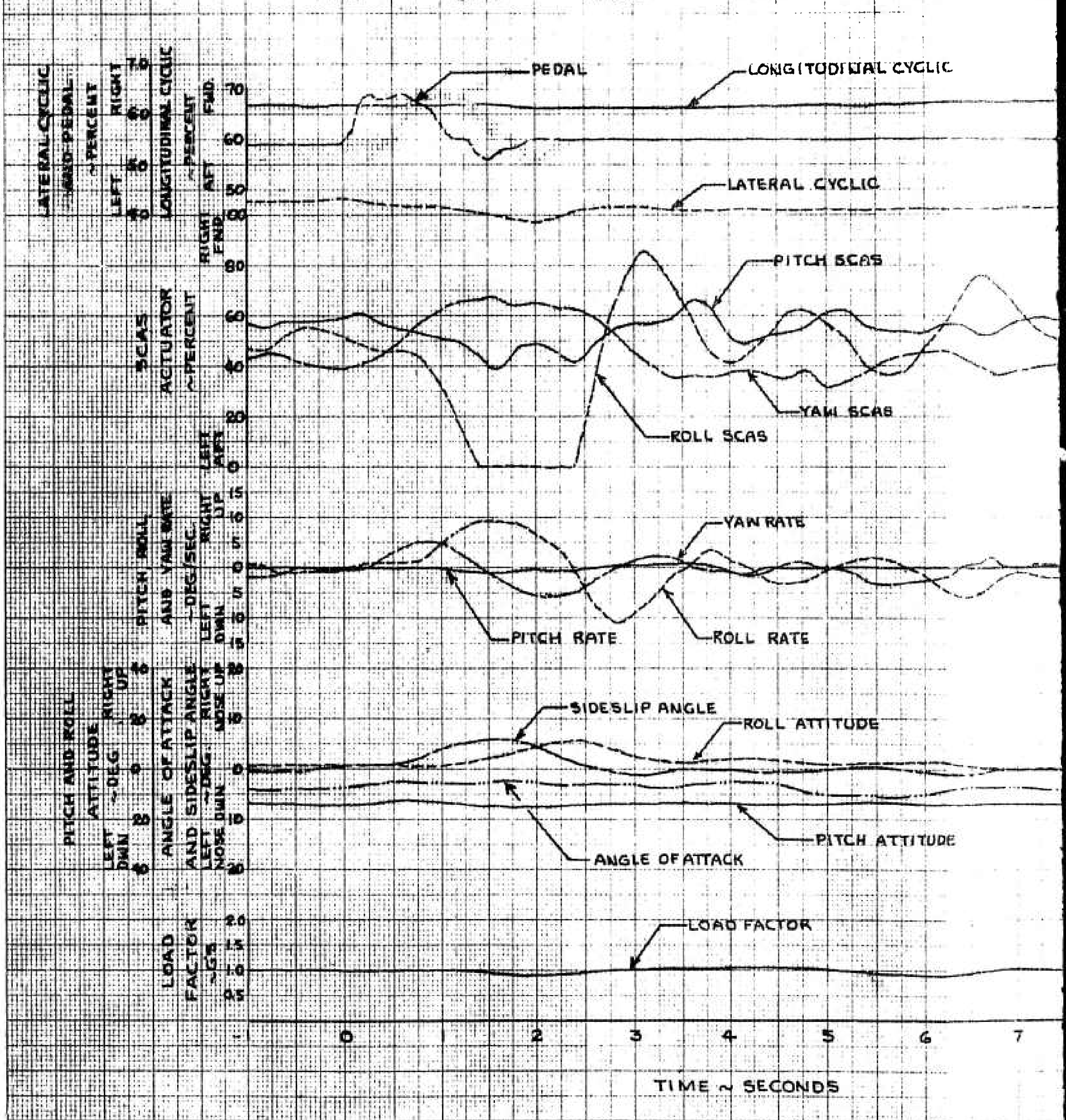
2

FIGURE NO. 14

RIGHT PEDAL PULSE

AH-1G USA S/N615246

AIRSPEED ~KCAS	GROSS WEIGHT ~LBS.	C.G. STATION ~IN.	DENSITY ALTITUDE ~FT.	ROTOR SPEED ~RPM	CONFIG
191	8990	194.5	3200	324	HC



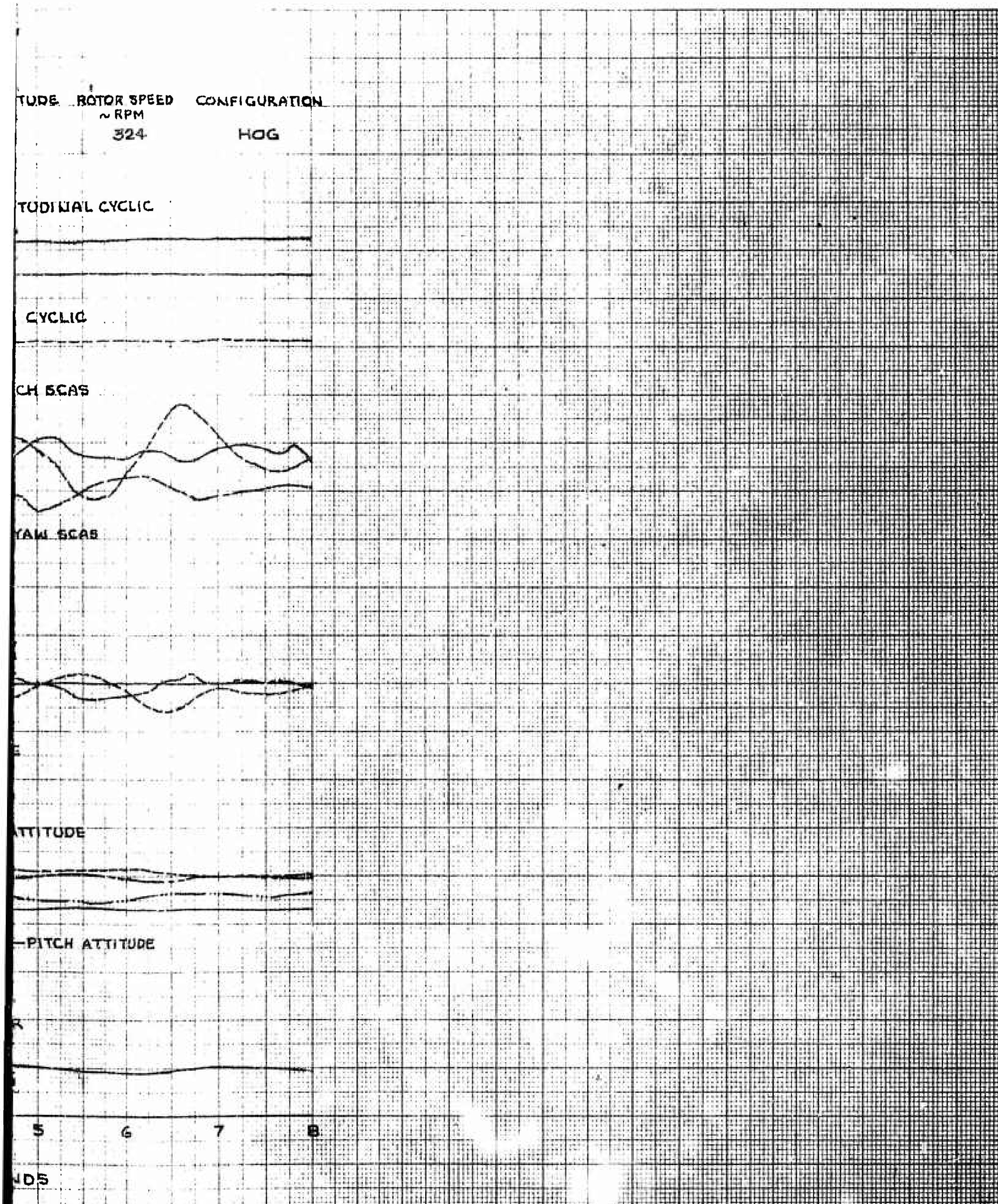

TUDE
ROTOR SPEED ~RPM
324
CONFIGURATION
HOG
TUDINAL CYCLIC
CYCLIC
CH SCAS
YAW SCAS
TTITUDE
PITCH ATTITUDE
5
6
7
8
NDS

FIGURE NO. 15

LONGITUDINAL RESPONSE

AH-1G USA S/N 615246

AVE. GROSS WEIGHT	AVE. C.G. STATION	AVE. DENSITY ALT.	ROTOR SPEED	CONFIGURATION
9320 LBS.	194.5 IN.	5230 FT.	324 RPM	HOG

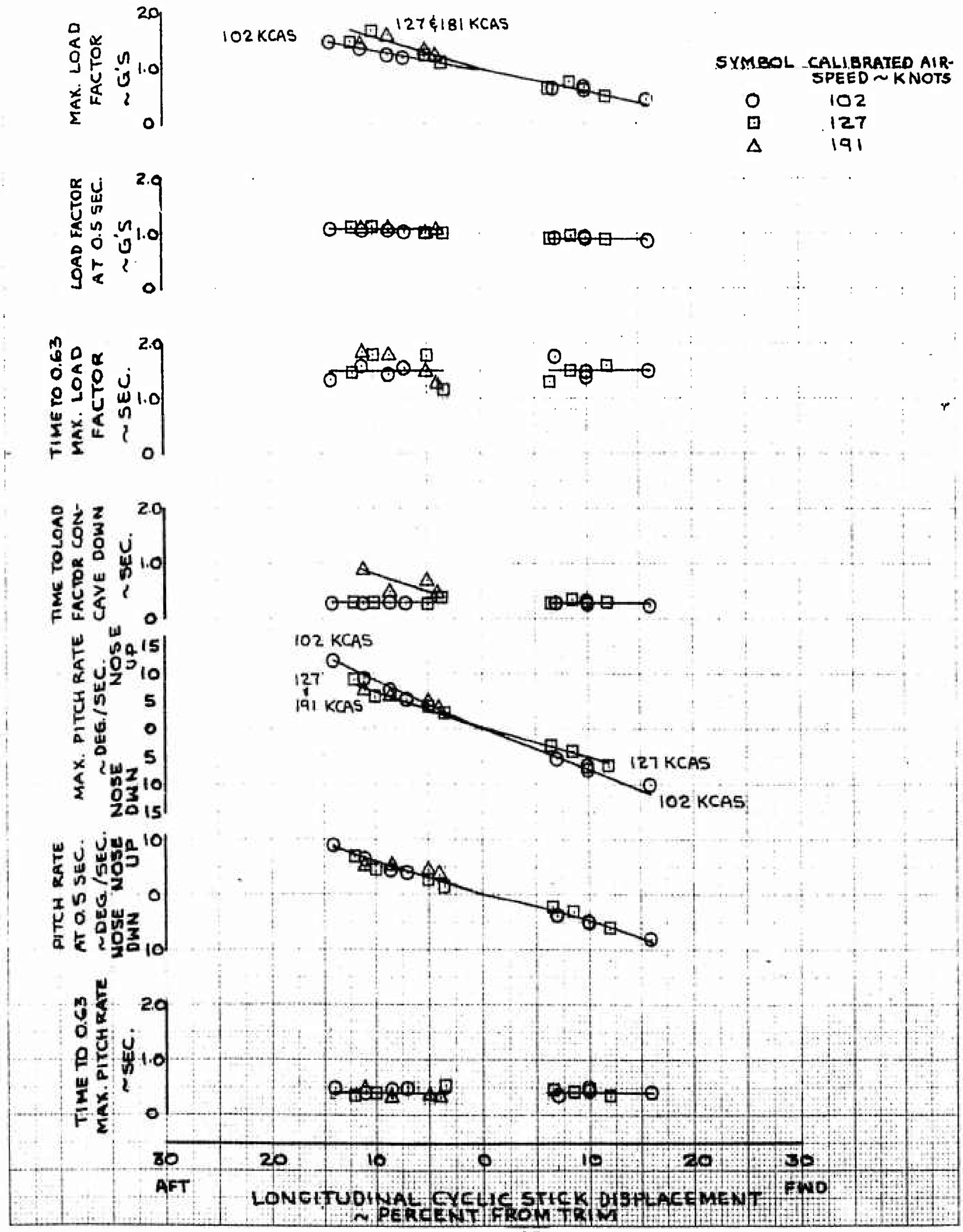
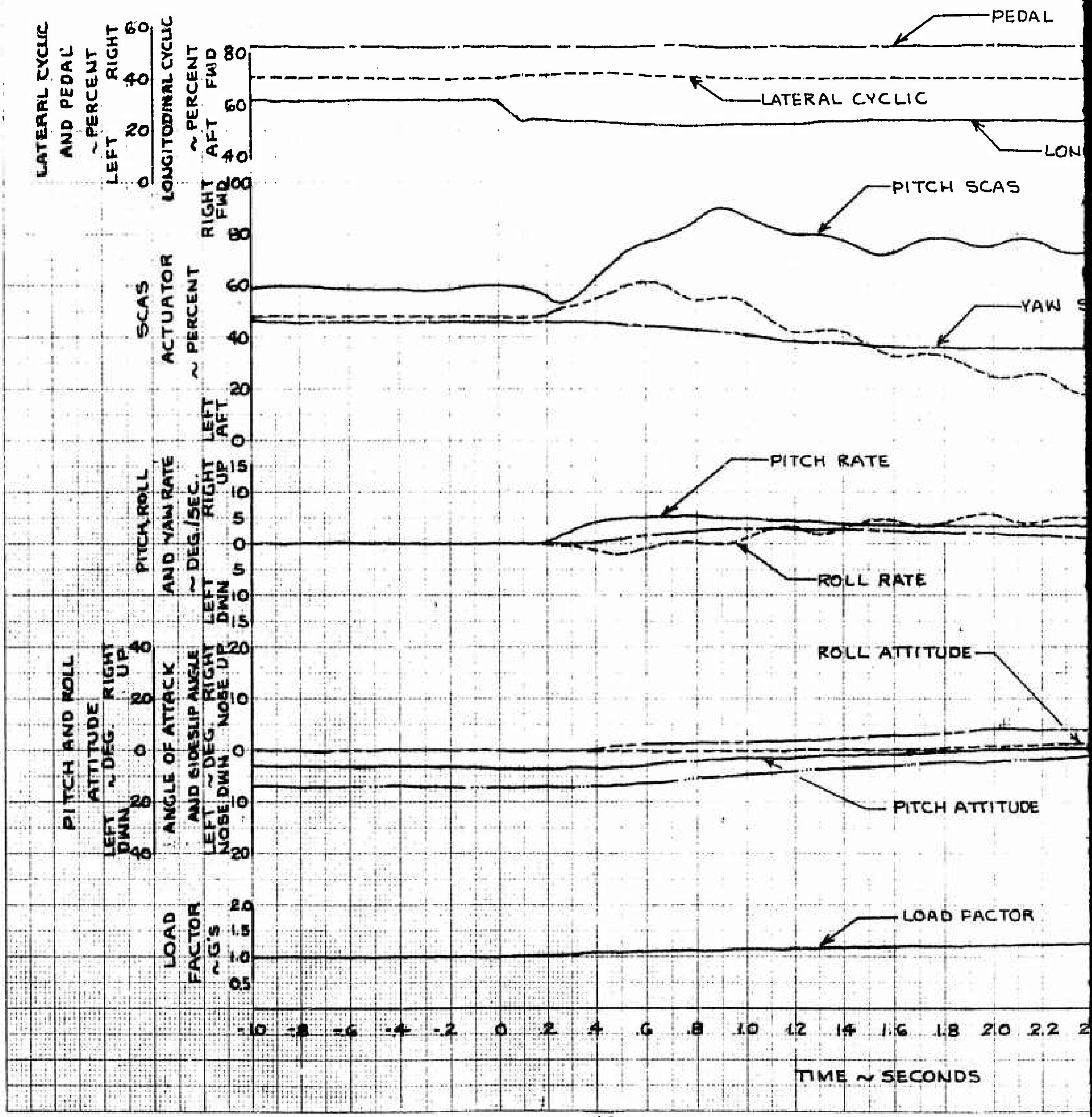


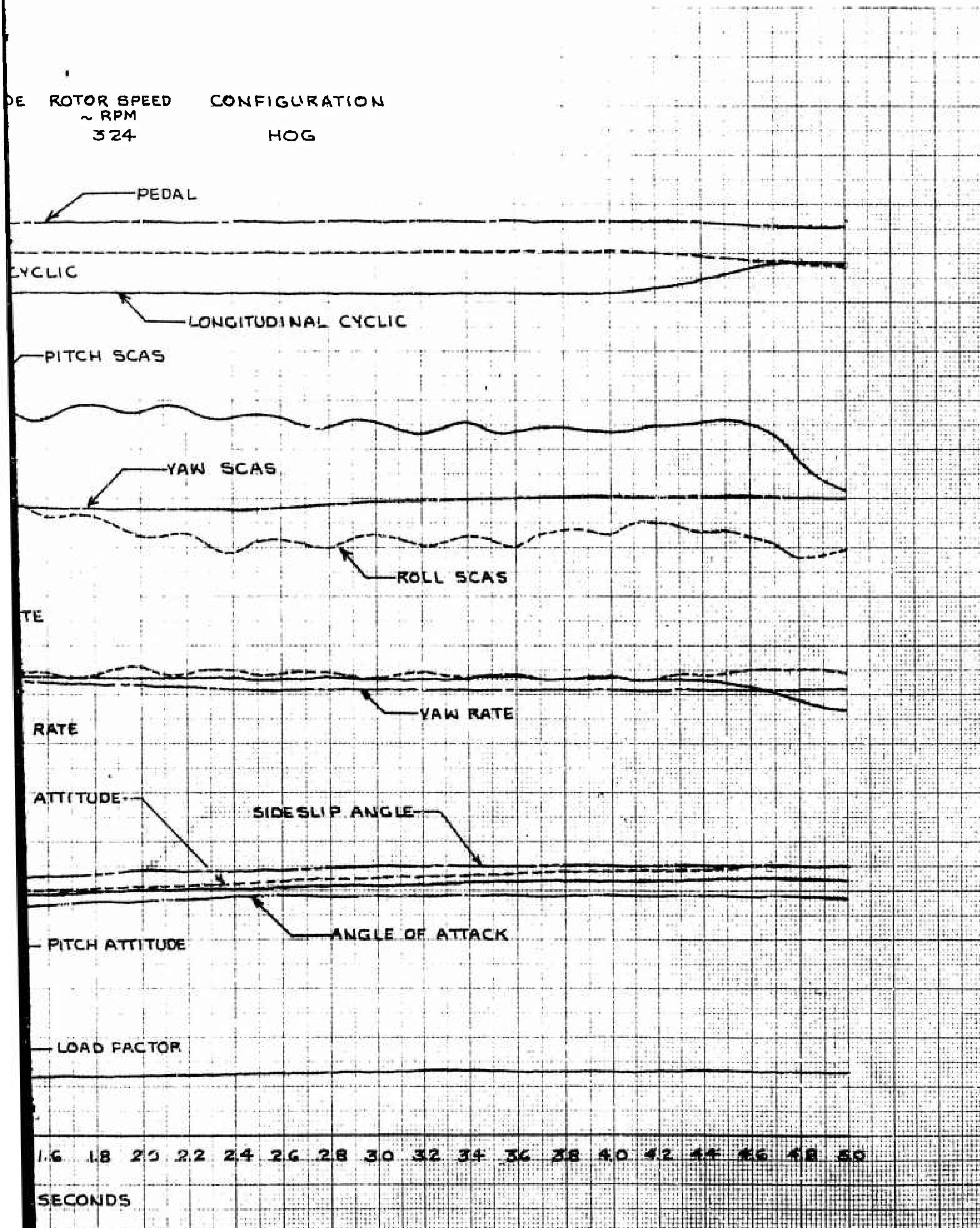
FIGURE NO. 16

AFT LONGITUDINAL STEP

AH-1G USA S/N 615246

AIRSPEED ~ KCAS	GROSS WEIGHT ~ LBS.	C.G. STATION ~ IN.	DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM
126	9100	194.6	5240	324





DE ROTOR SPEED ~ RPM
324
CONFIGURATION
HOG
PEDAL
CYCLIC
LONGITUDINAL CYCLIC
PITCH SCAS
YAW SCAS
ROLL SCAS
TE
YAW RATE
RATE
ATTITUDE
SIDESLIP ANGLE
ANGLE OF ATTACK
PITCH ATTITUDE
LOAD FACTOR
1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0 4.2 4.4 4.6 4.8 5.0
SECONDS

2

FIGURE NO. 17
LATERAL RESPONSE
AH-1G USA S/N 615246

SYM.	AIRSPEED ~KCAS	GROSS WEIGHT ~LBS.	C.G. STATION ~IN.	DENSITY ALTITUDE ~FT.	ROTOR SPEED ~RPM	CONFIGURATION
○	103.0	9430	194.5	5240	324	HOG
□	126.5	8930	194.5	5240	324	HOG
△	191.0	9220	194.7	5000	324	HOG

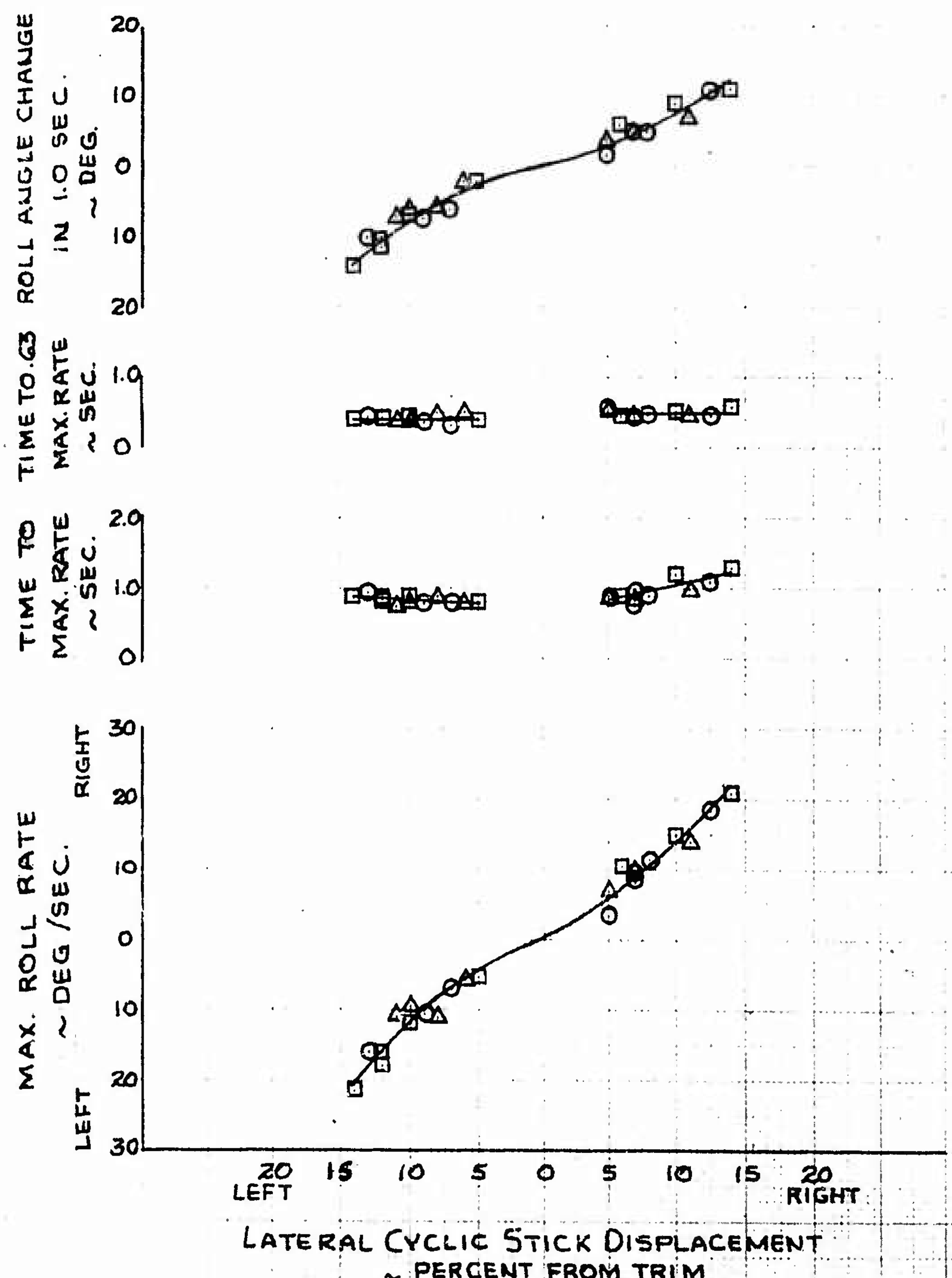
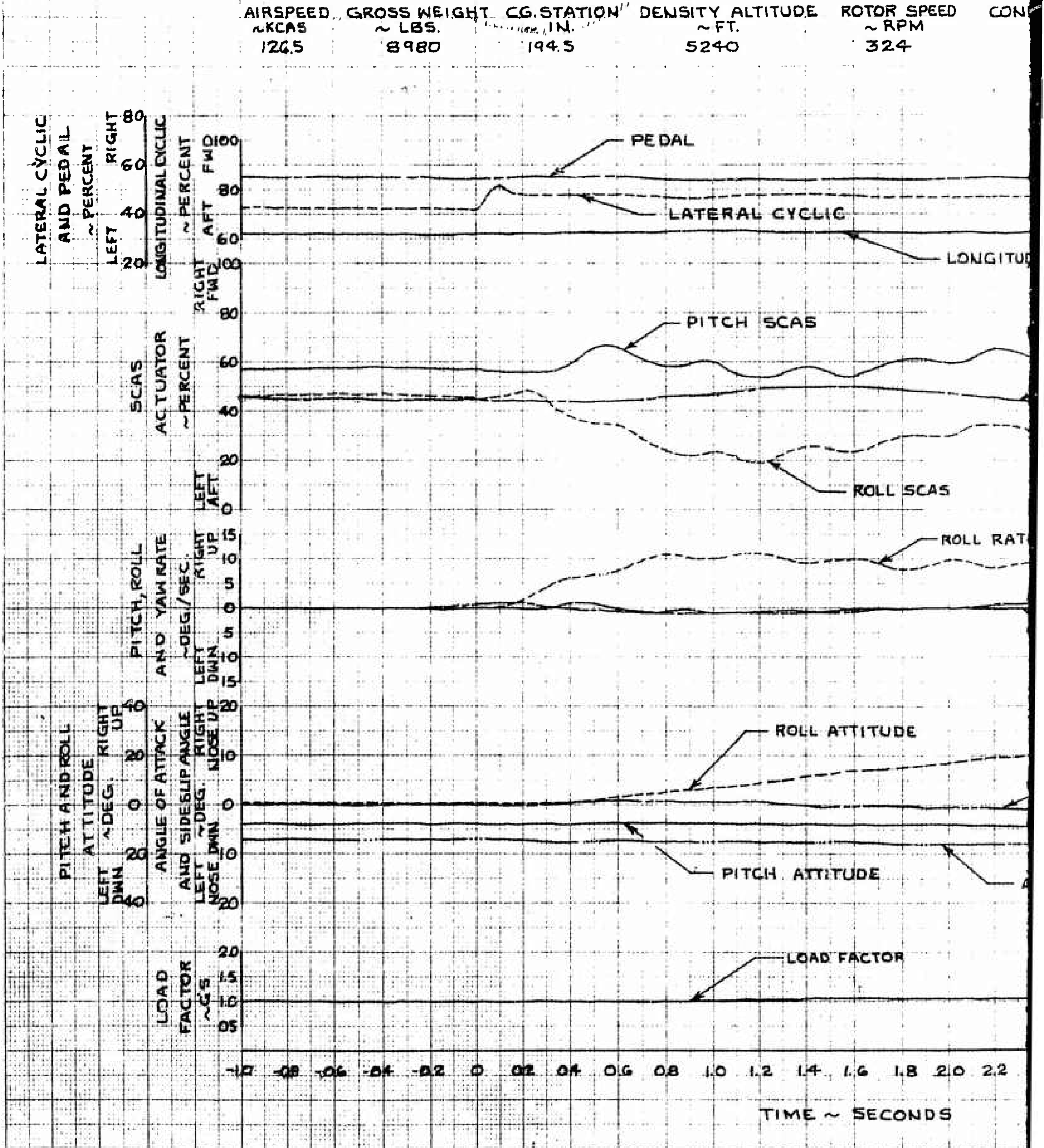
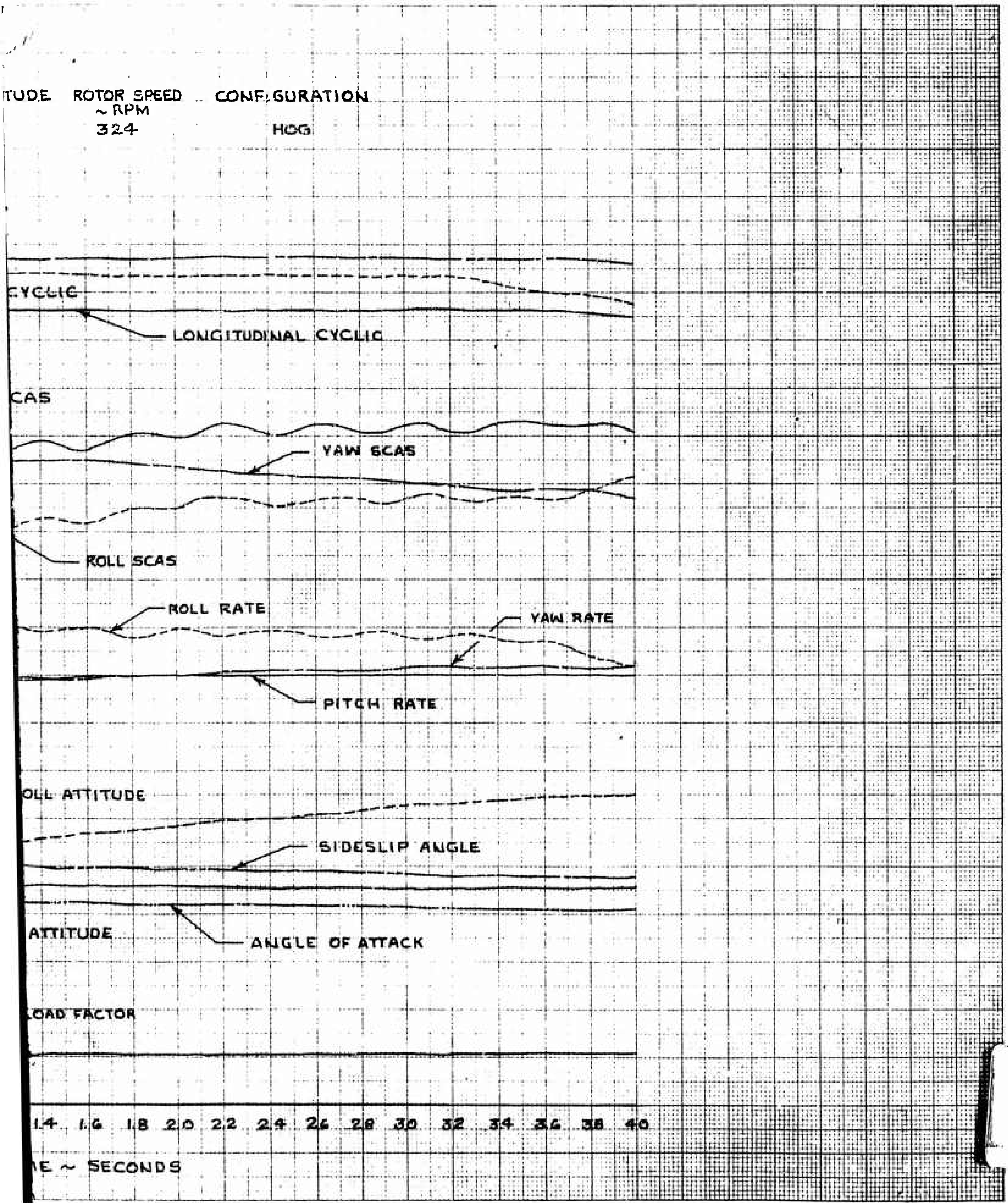


FIGURE NO. 18
RIGHT LATERAL STEP
AH-1G USA S/N 615246

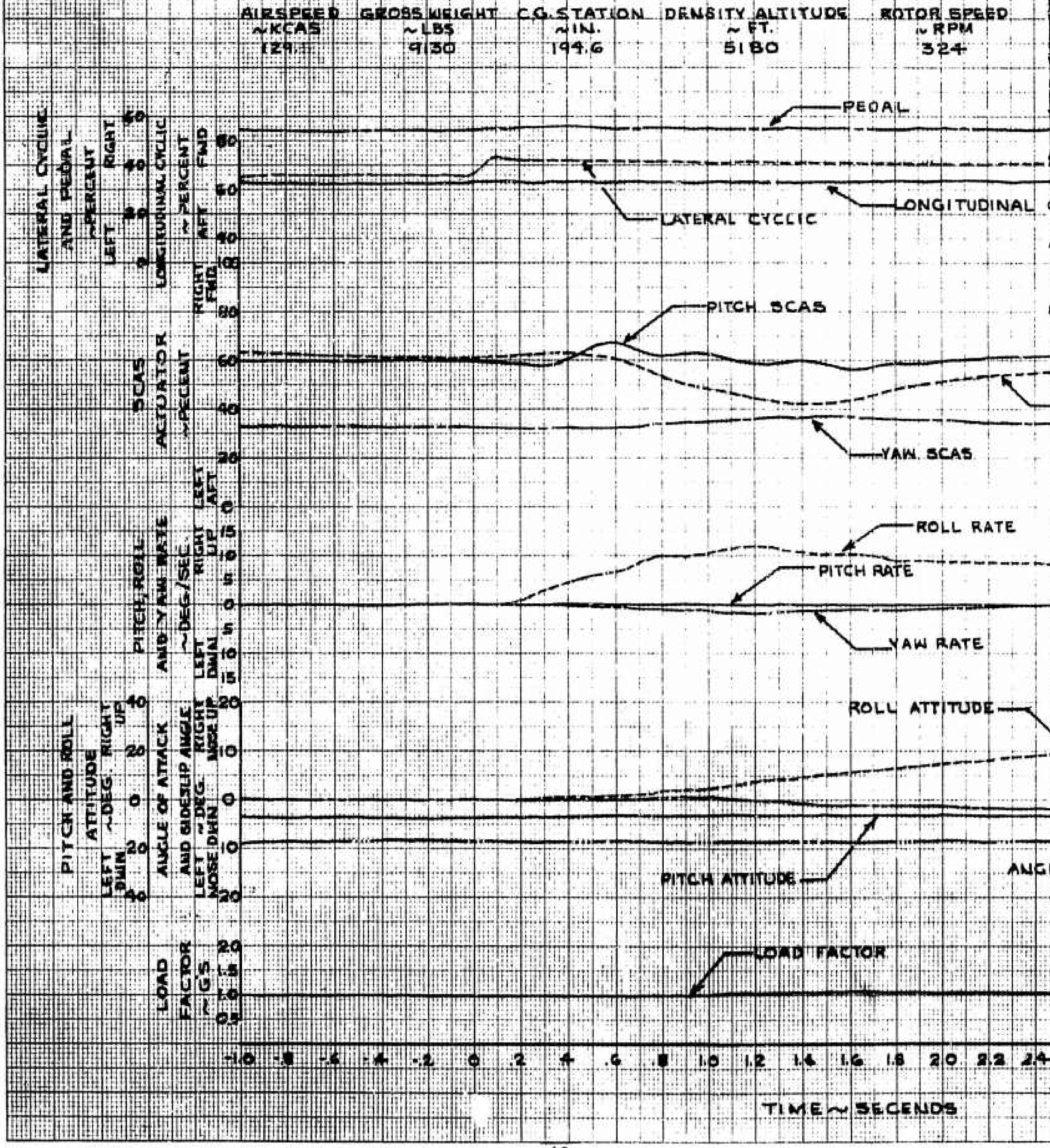


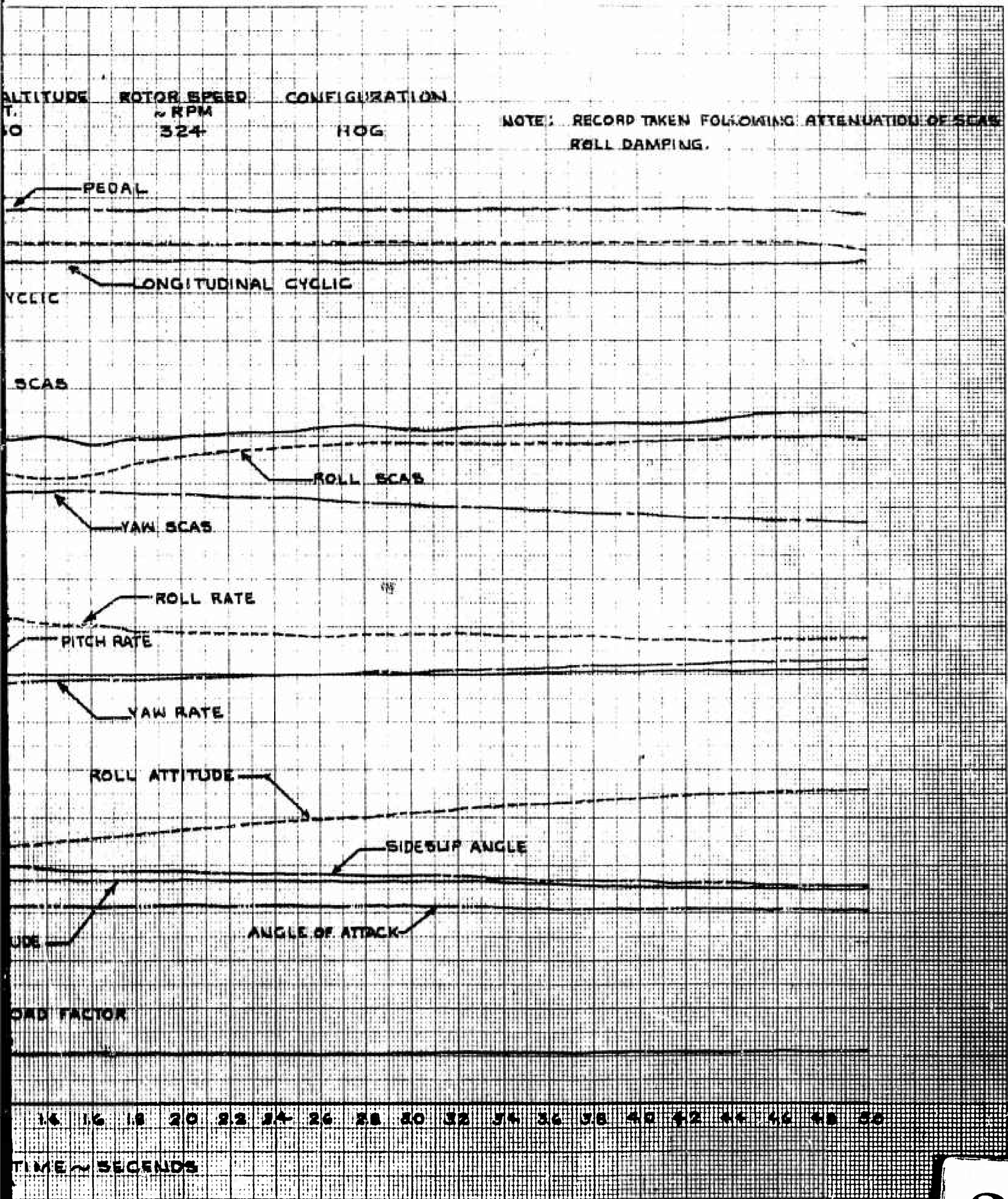


TUDE
ROTOR SPEED ~ RPM
324
CONFIGURATION
HOG
CYCLIC
LONGITUDINAL CYCLIC
CAS
YAW SCAS
ROLL SCAS
ROLL RATE
YAW RATE
PITCH RATE
OLL ATTITUDE
SIDESLIP ANGLE
ATTITUDE
ANGLE OF ATTACK
LOAD FACTOR
1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0
E ~ SECONDS

2

FIGURE NO. 19
RIGHT LATERAL STEP
AH-1G USA S/N 615246

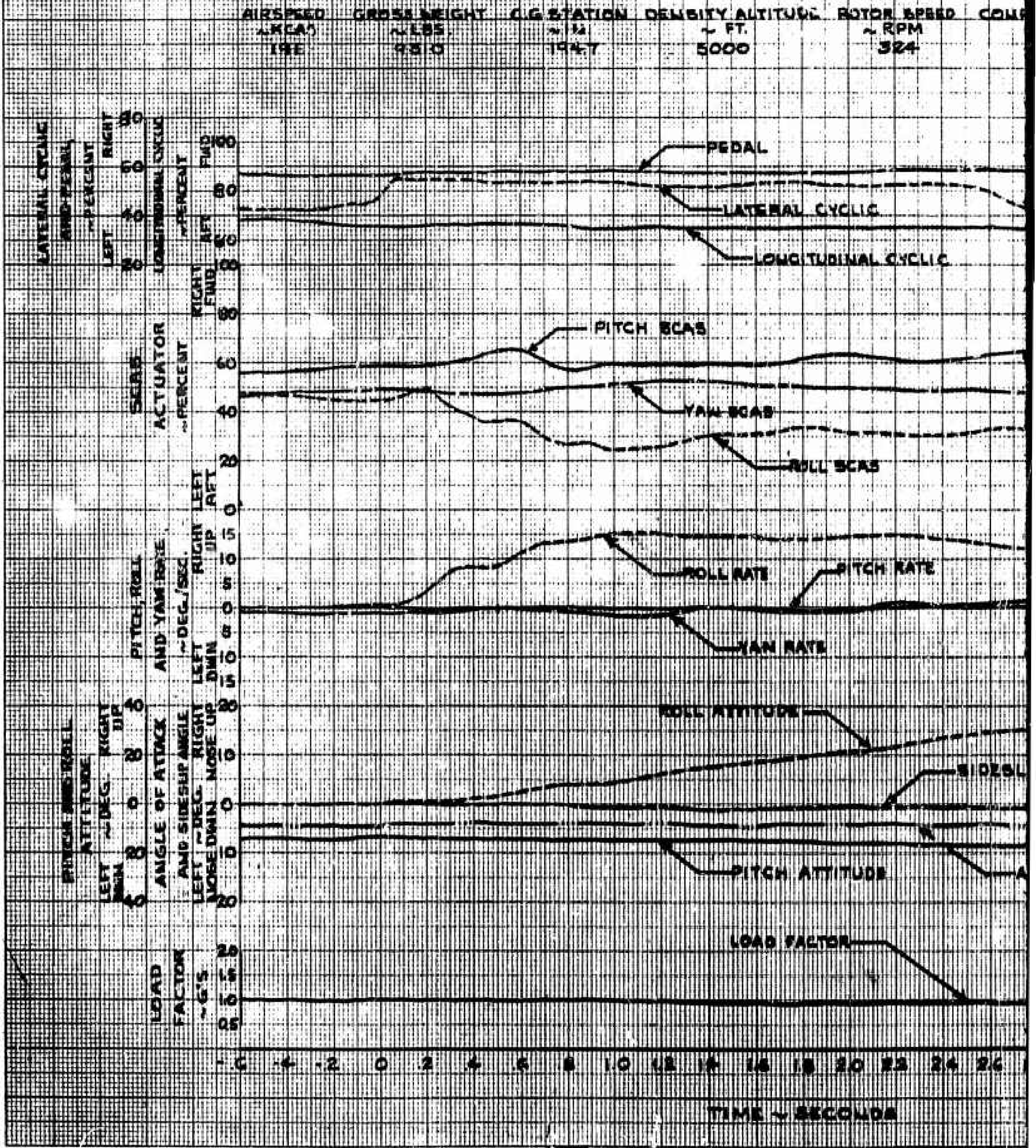




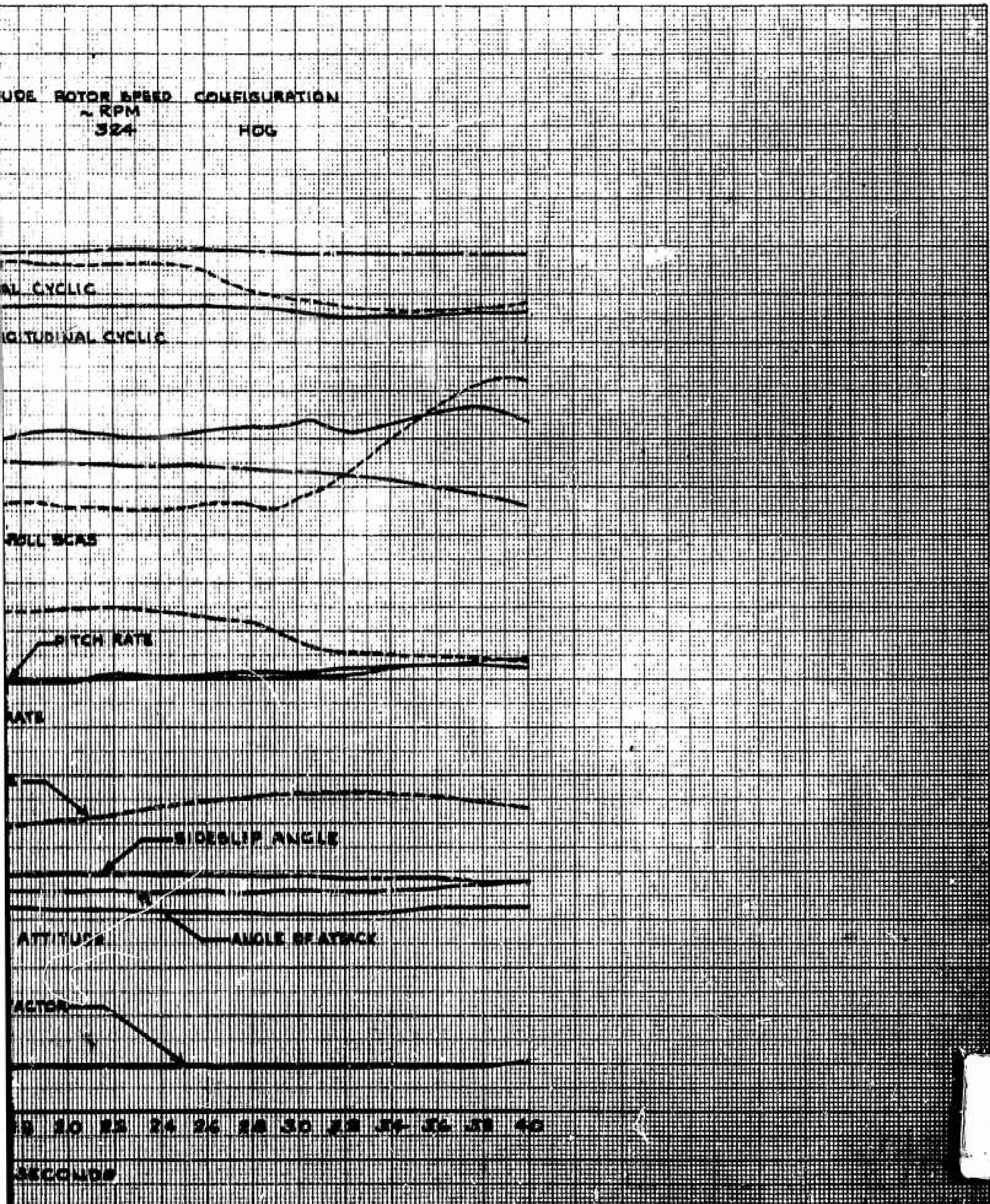
ALTITUDE
T.
O
ROTOR SPEED
~ RPM
324
CONFIGURATION
HOG
NOTE: RECORD TAKEN FOLLOWING ATTENUATION OF SCAS ROLL DAMPING.
PEDAL
LONGITUDINAL CYCLIC
YCLIC
SCAS
ROLL SCAS
YAW SCAS
ROLL RATE
PITCH RATE
YAW RATE
ROLL ATTITUDE
SIDESLIP ANGLE
UDE
ANGLE OF ATTACK
ORD FACTOR
14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50
TIME ~ SECONDS

2

FIGURE No. 20
RIGHT LATERAL STEP
AH-1G USA S/N 616246



1



UDE ROTOR SPEED ~ RPM 324
CONFIGURATION HOG
AL CYCLIC
IGITUDINAL CYCLIC
ROLL SCAS
PITCH RATE
RATE
SIDESLIP ANGLE
ATTITUDE
ANGLE OF ATTACK
FACTOR
20 22 24 26 28 30 32 34 36 38 40
SECONDS

2

FIGURE NO. 21
DIRECTIONAL RESPONSE
AH-1G USA S/N 615246

SYM.	AIRSPEED ~KCAS	GROSS WEIGHT ~LBS.	C.G. STATION ~IN.	DENSITY ALTITUDE ~FT.	ROTOR SPEED ~RPM	CONFIGURATION
○	103.0	9320	194.8	5240	324	HOG
□	126.5	8770	194.2	5240	324	HOG
△	191.0	9040	194.5	5000	324	HOG

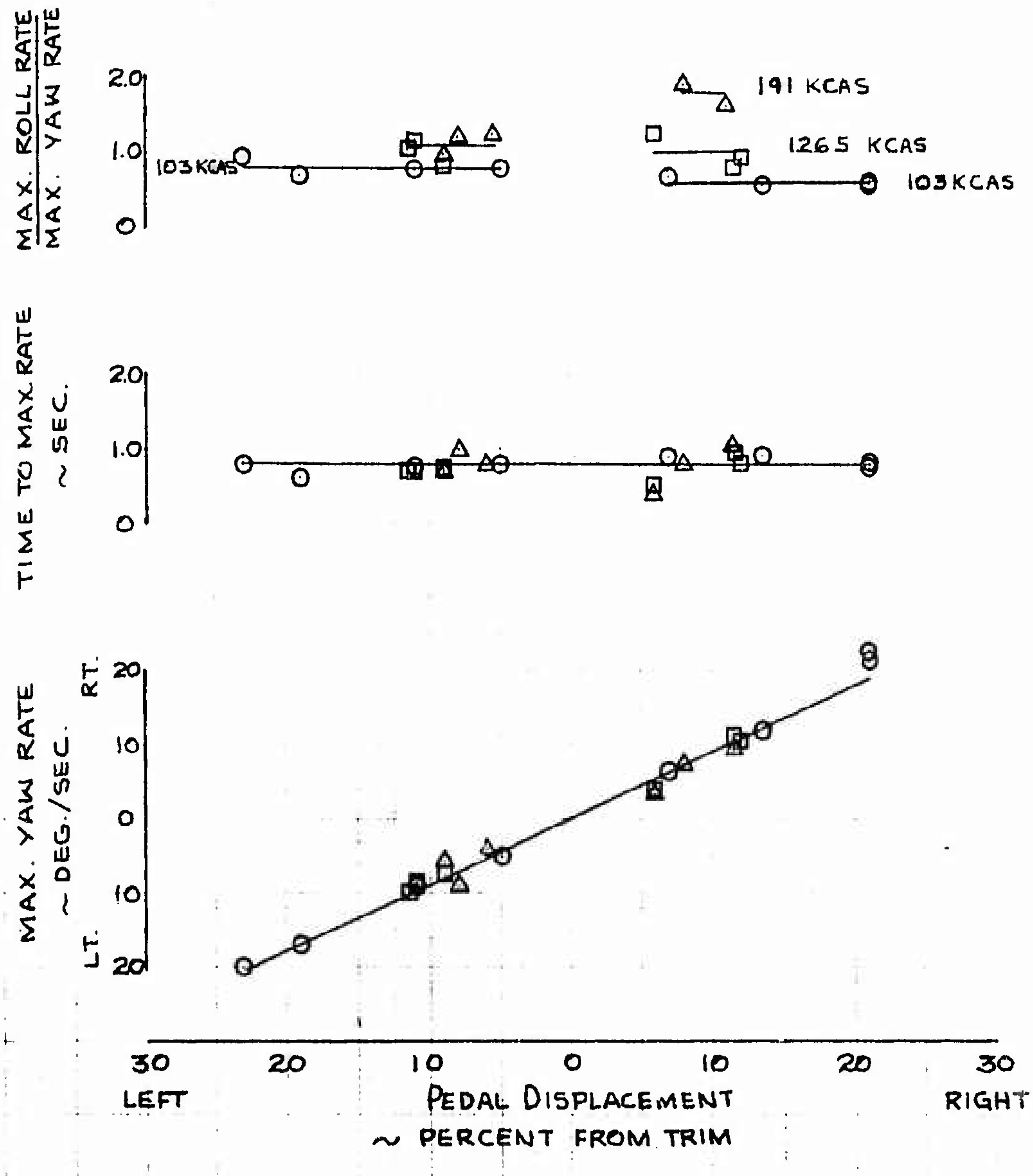


FIGURE No. 22

MANEUVERING STABILITY

AH-1G USA S/N 615246

AIRSPEED ~KCAS	GROSS WEIGHT ~LBS.	C.G. STATION ~IN.	DENSITY ALTITUDE ~FT.	ROTOR SPEED ~RPM	CONFIGURATION
103	9110	194.7	5600	324	HOG

NOTES:

1. O DENOTES WIND-UP TURN METHOD
2. □ DENOTES SYMETRICAL PULL-UP METHOD
3. CYCLIC FORCE TRIM ON.
4. CYCLIC ADJUSTABLE FRICTION FULL OFF.
5. LONGITUDINAL CYCLIC STICK FORCE MEASURED AT CENTER OF HAND GRIP.

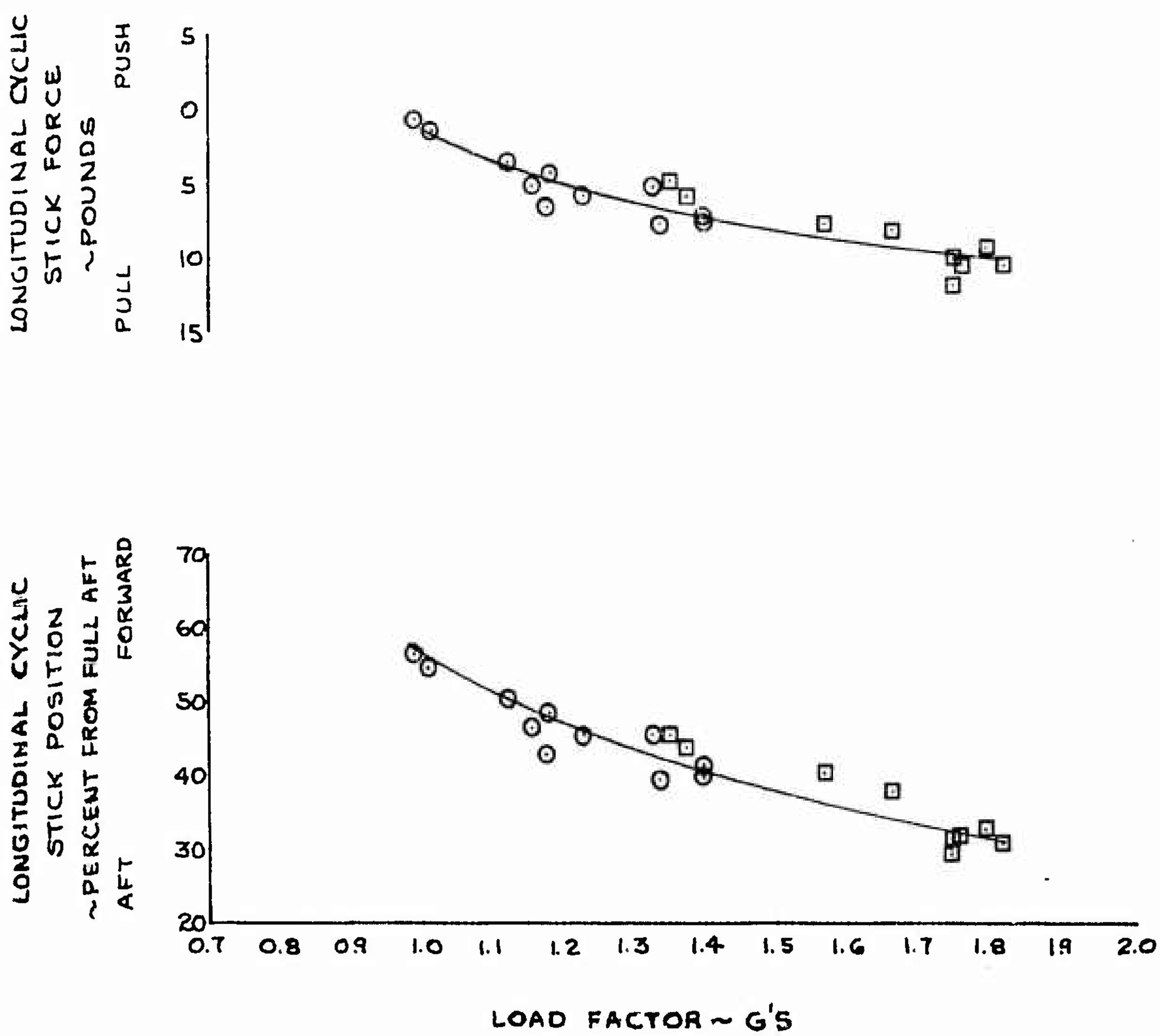
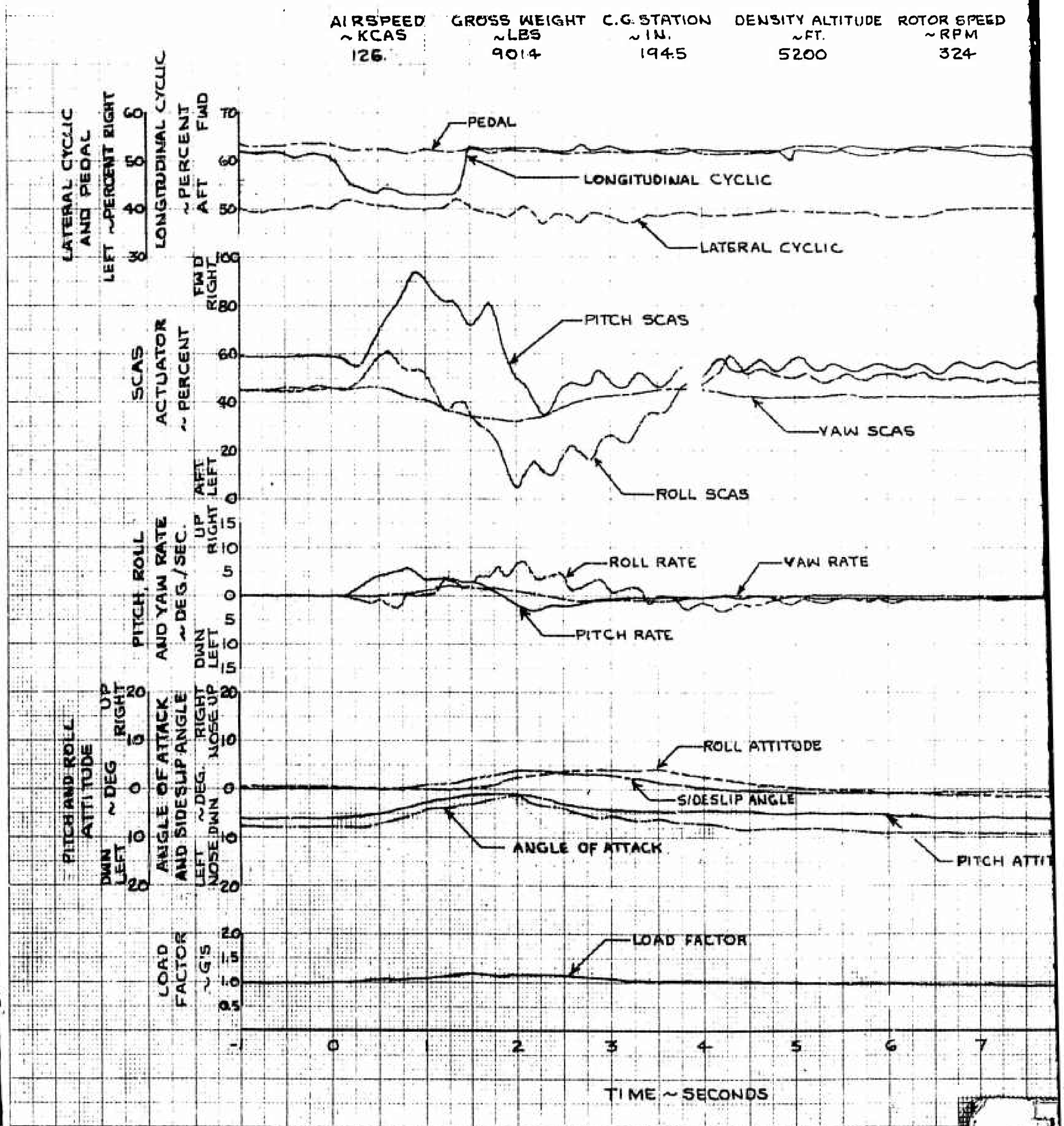
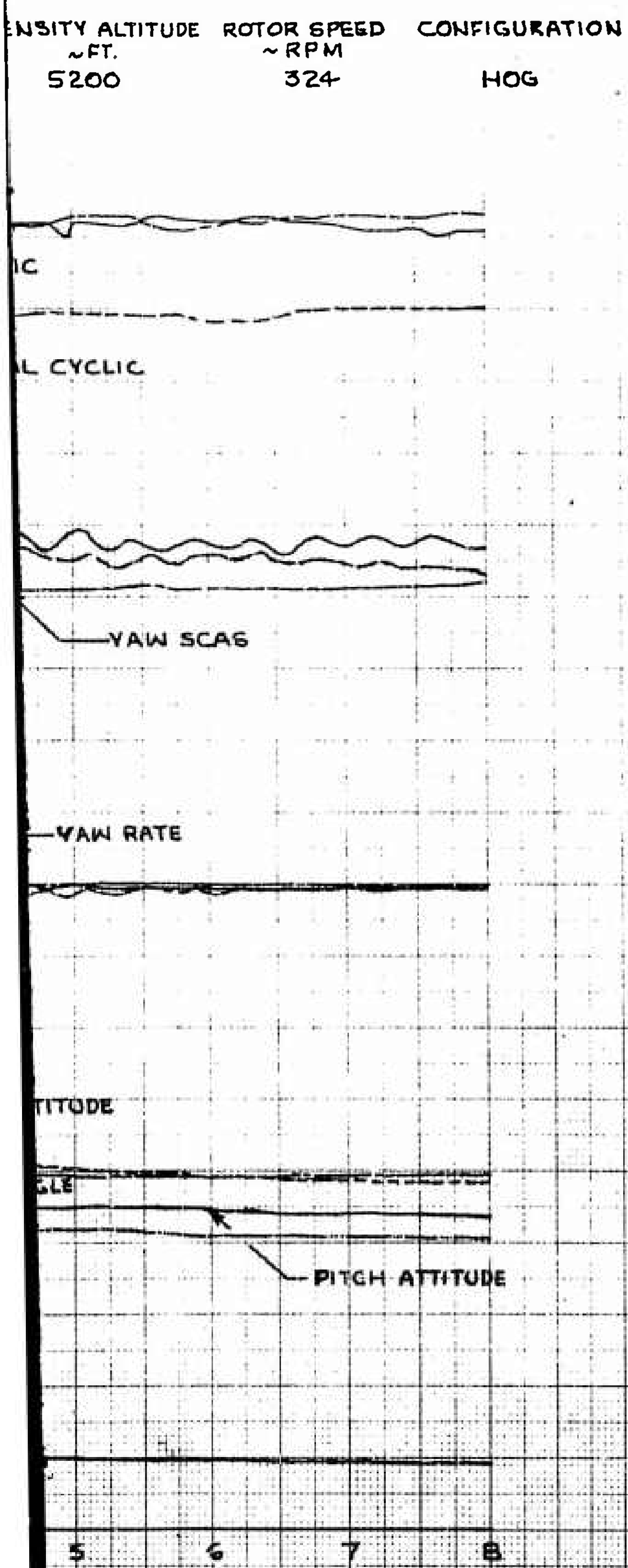


FIGURE No. 23

AFT LONGITUDINAL PULSE

AH-1G USA S/N 615246




ENSITY ALTITUDE ~FT.
5200
ROTOR SPEED ~RPM
324
CONFIGURATION
HOG
IC
L CYCLIC
YAW SCAS
YAW RATE
TITUDE
GLE
PITCH ATTITUDE
5
6
7
8

2

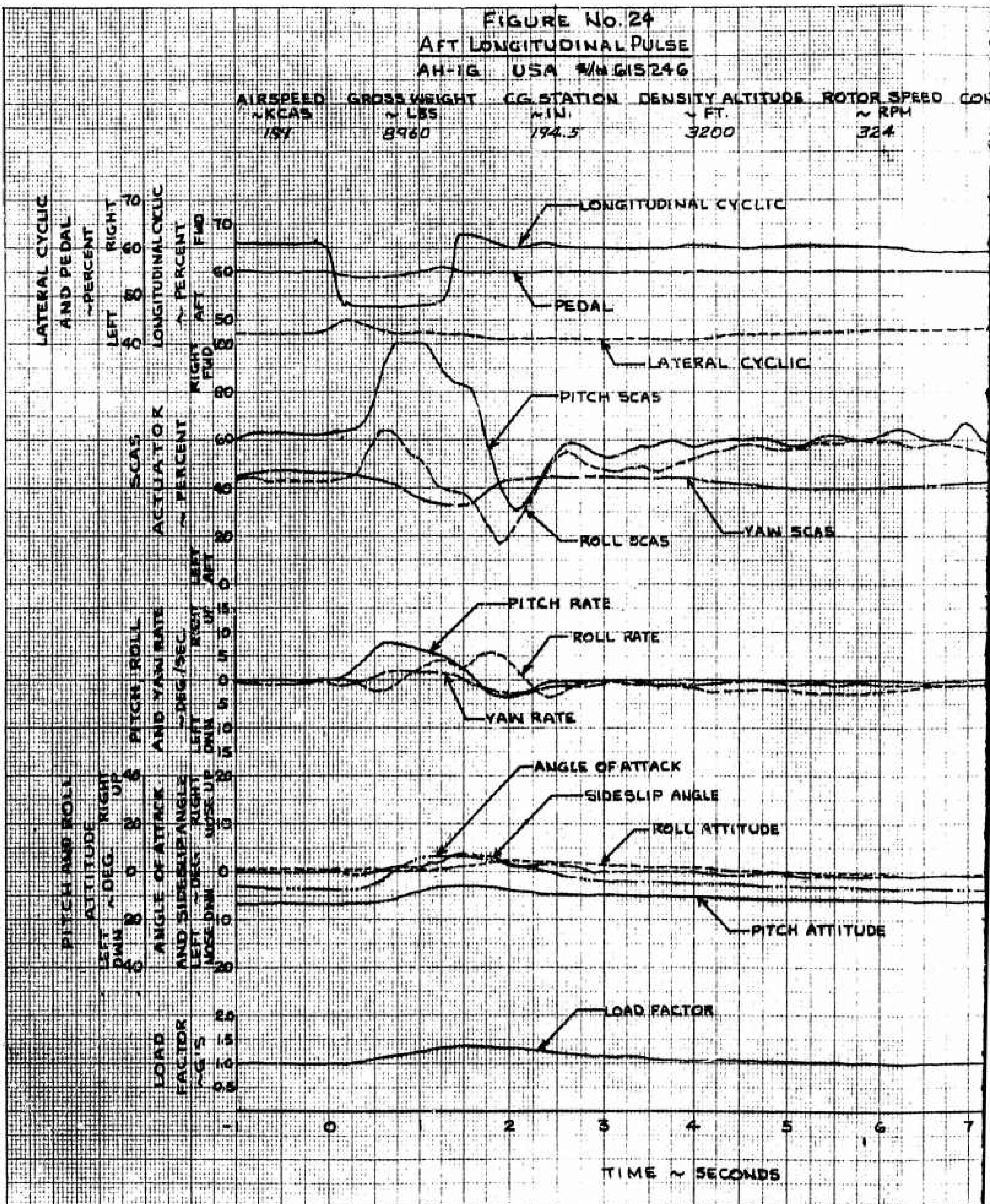
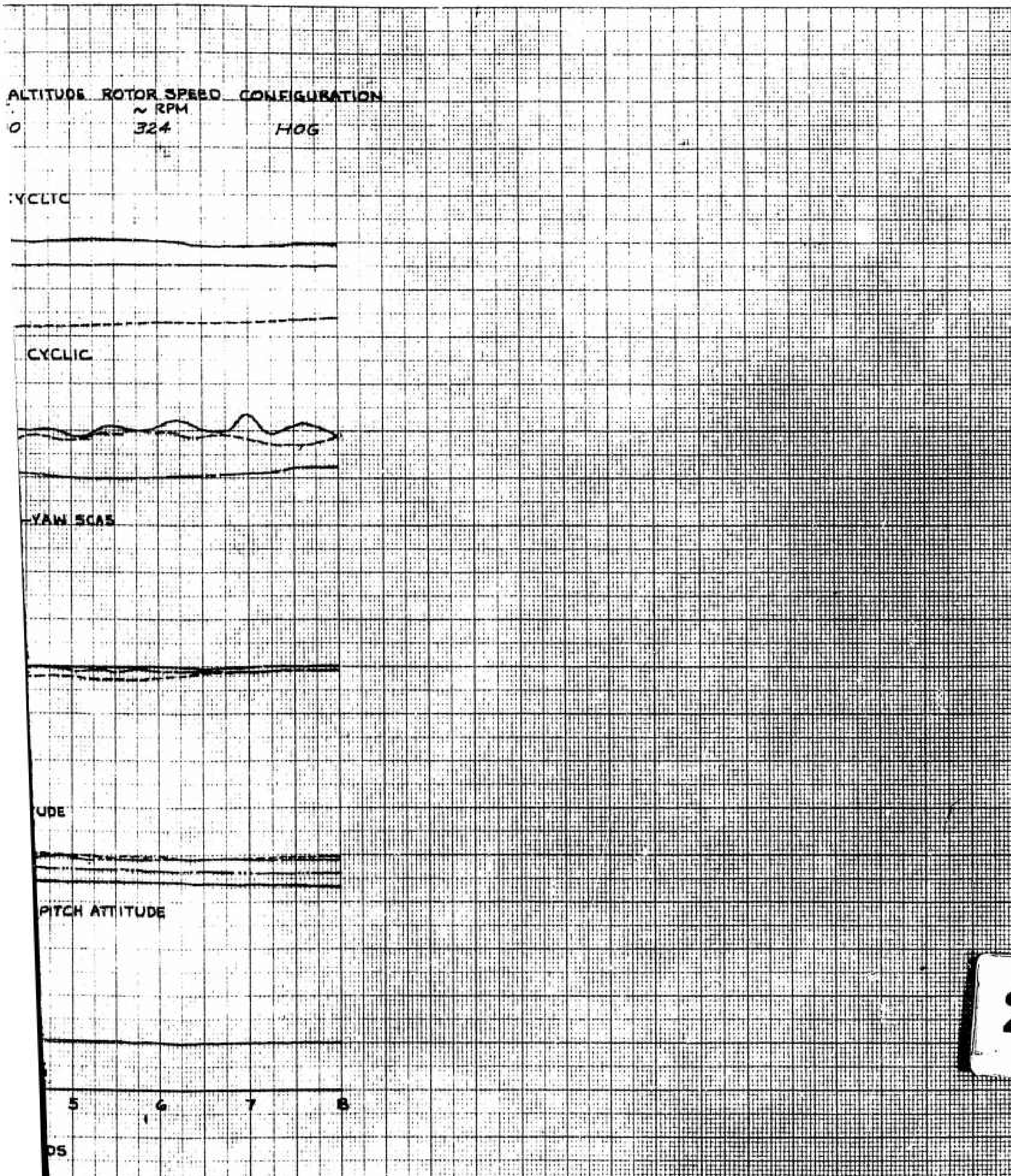


FIGURE No. 24
AFT LONGITUDINAL PULSE
AH-1G USA S/N 615246
AIRSPEED ~KCAS 151
GROSS WEIGHT ~ LBS 8960
C.G. STATION ~IN. 194.5
DENSITY ALTITUDE ~ FT. 3200
ROTOR SPEED ~ RPM 324
LATERAL CYCLIC AND PEDAL ~PERCENT
LEFT RIGHT
LONGITUDINAL CYCLIC ~ PERCENT
AFT FWD
SCAS ACTUATOR ~ PERCENT
PITCH, ROLL AND YAW RATE ~DEG./SEC.
PITCH AND ROLL ATTITUDE ~ DEG.
ANGLE OF ATTACK AND SIDESLIP ANGLE ~ DEG.
LOAD FACTOR ~G'S
LONGITUDINAL CYCLIC
PEDAL
LATERAL CYCLIC
PITCH SCAS
ROLL SCAS
YAW SCAS
PITCH RATE
ROLL RATE
YAW RATE
ANGLE OF ATTACK
SIDESLIP ANGLE
ROLL ATTITUDE
PITCH ATTITUDE
LOAD FACTOR
TIME ~ SECONDS


ALTITUDE ROTOR SPEED CONFIGURATION
~ RPM
0
324
HOG
:YCLIC
CYCLIC
-YAW SCAS
UDE
PITCH ATTITUDE
5
6
7
8
DS

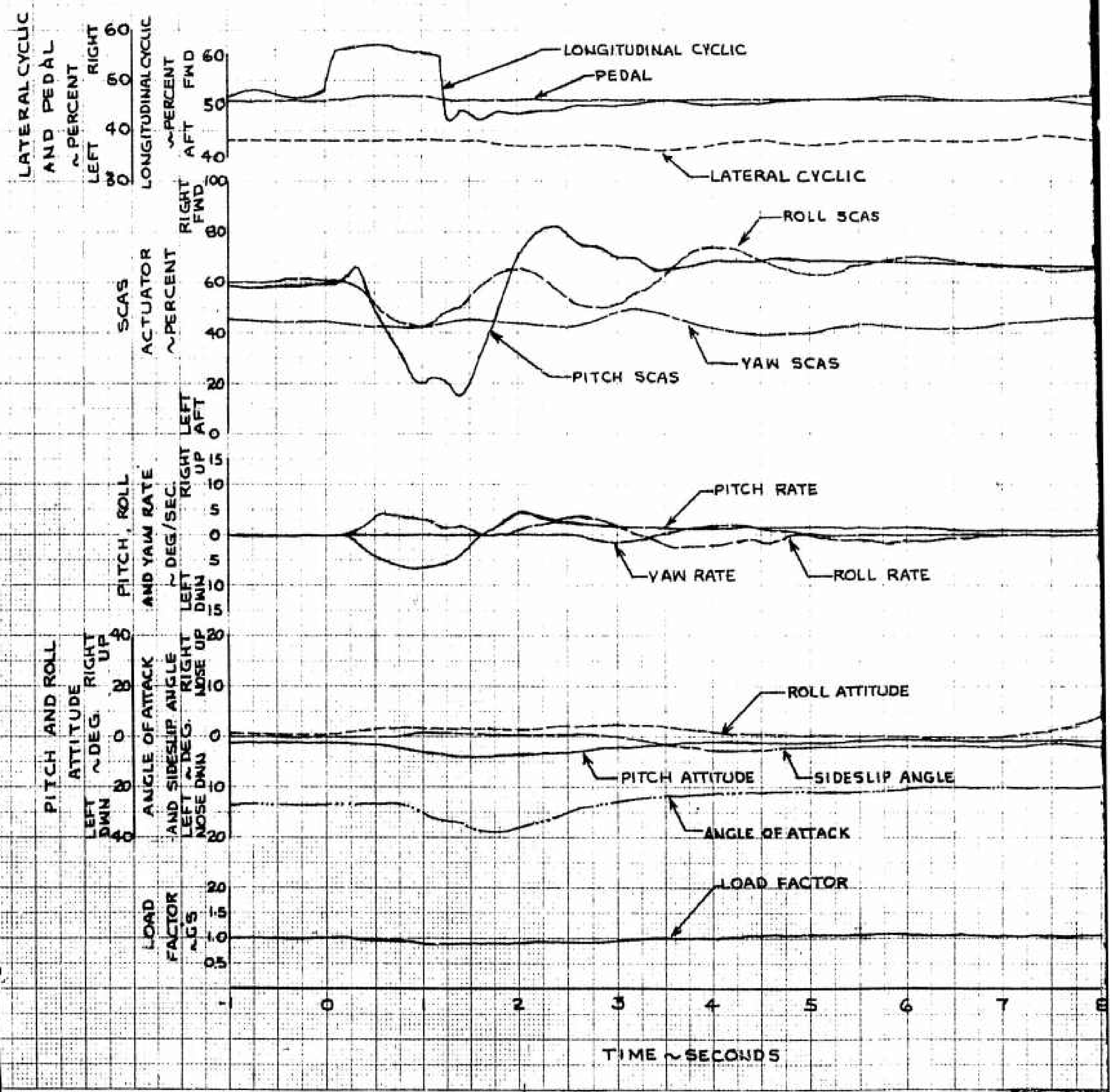
2

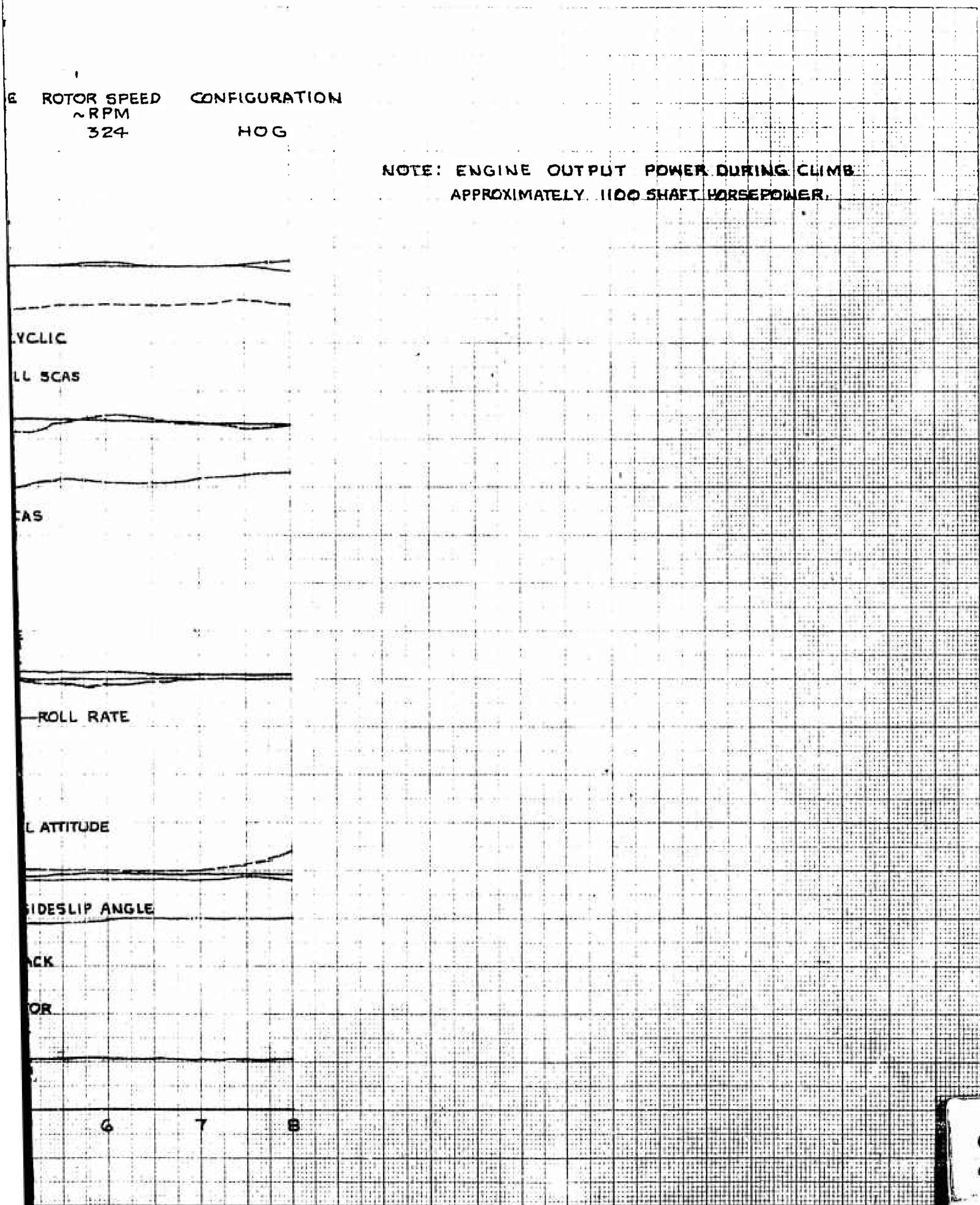
FIGURE NO. 25

FORWARD LONGITUDINAL PULSE IN CLIMB

AH-1G USA S/N 615246

AIRSPEED ~KCAS	GROSS WEIGHT ~LBS	C.G. STATION ~IN.	DENSITY ALTITUDE ~FT.	ROTOR SPEED ~RPM	CONFIGUR
71	9260	194.7	5120	324	HO



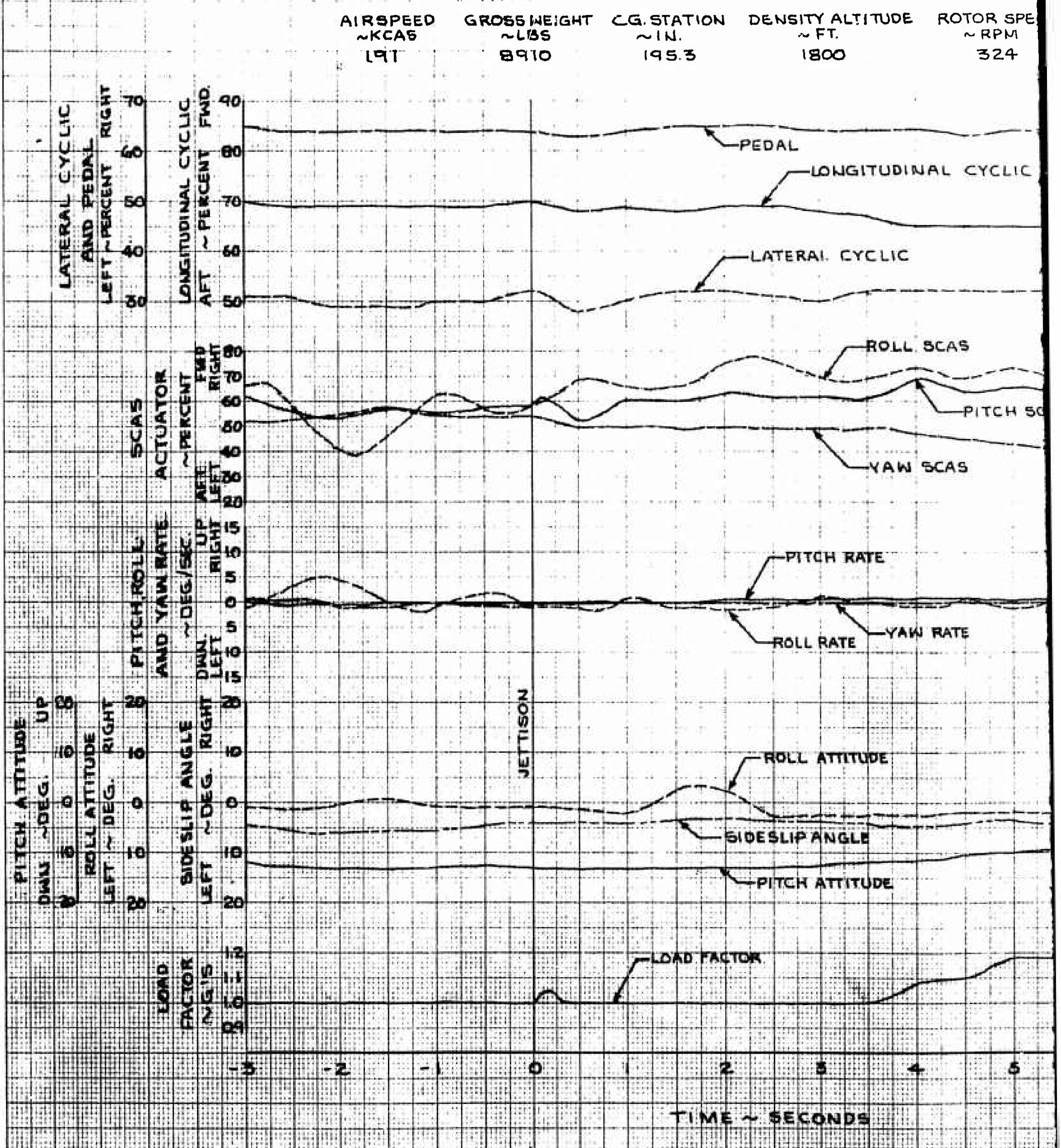

ROTOR SPEED ~RPM
324
CONFIGURATION
HOG
NOTE: ENGINE OUTPUT POWER DURING CLIMB APPROXIMATELY 1100 SHAFT HORSEPOWER.
ROLL RATE
SIDESLIP ANGLE
6
7
8

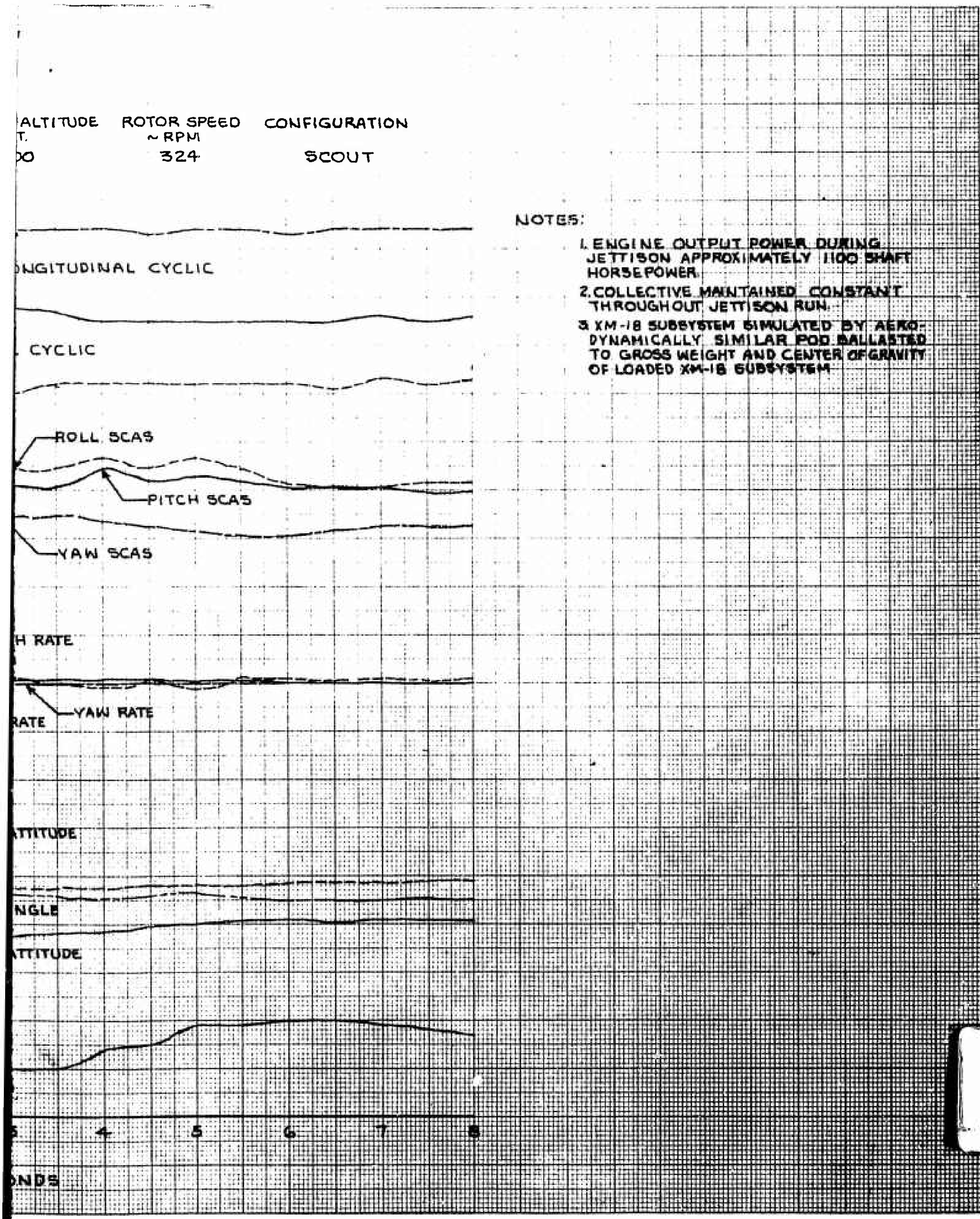
2

FIGURE No 26

XM-18 SUBSYSTEM JETTISON IN LEFT SIDESLIP

AH-1G USA S/N 615246



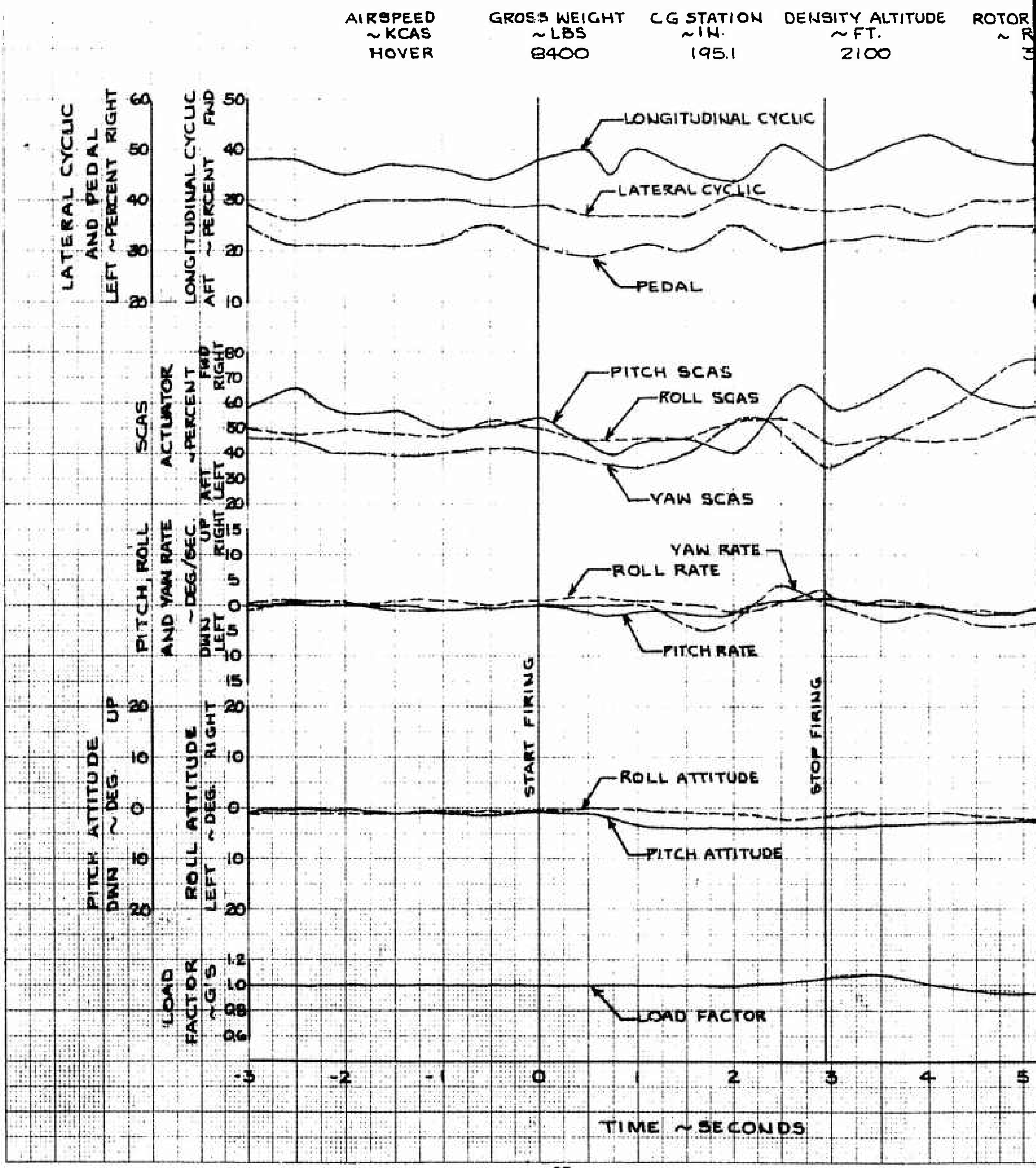

ALTITUDE
T.
00
ROTOR SPEED
~ RPM
324
CONFIGURATION
SCOUT
NOTES:
1. ENGINE OUTPUT POWER DURING JETTISON APPROXIMATELY 1100 SHAFT HORSEPOWER.
2. COLLECTIVE MAINTAINED CONSTANT THROUGHOUT JETTISON RUN.
3. XM-18 SUBSYSTEM SIMULATED BY AERODYNAMICALLY SIMILAR POD BALLASTED TO GROSS WEIGHT AND CENTER OF GRAVITY OF LOADED XM-18 SUBSYSTEM.
ONGITUDINAL CYCLIC
CYCLIC
ROLL SCAS
PITCH SCAS
YAW SCAS
H RATE
YAW RATE
RATE
TTITUDE
NGLE
TTITUDE
3
4
5
6
7
8
ONDS

2

FIGURE NO. 27

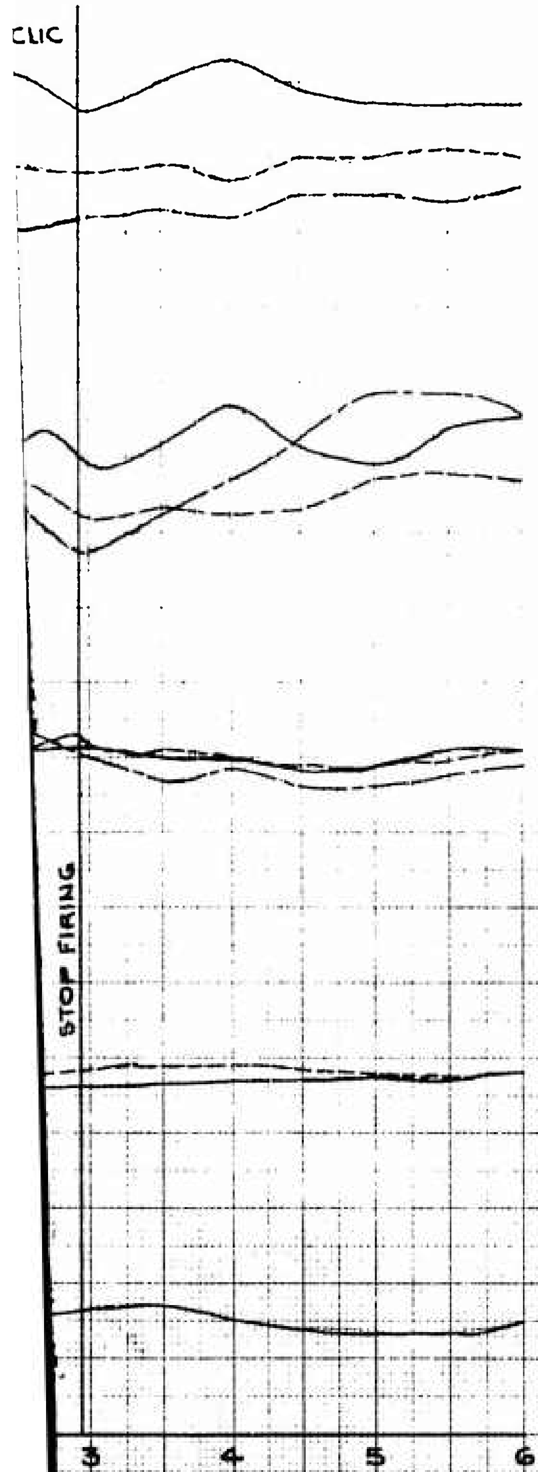
XM-159 SUBSYSTEM (INBOARD) RIPPLE FIRING

AH-1G USA S/N615246



IG

DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM	CONFIGURATION
2100	324	HOG



NOTES:

1. FULL INBOARD COMPLEMENT (19 PAIRS) OF 2.75 INCH F.F.A.R. FIRED.
2. HOVERING SKID HEIGHT AT TIME OF FIRING WAS APPROXIMATELY 4 FEET.

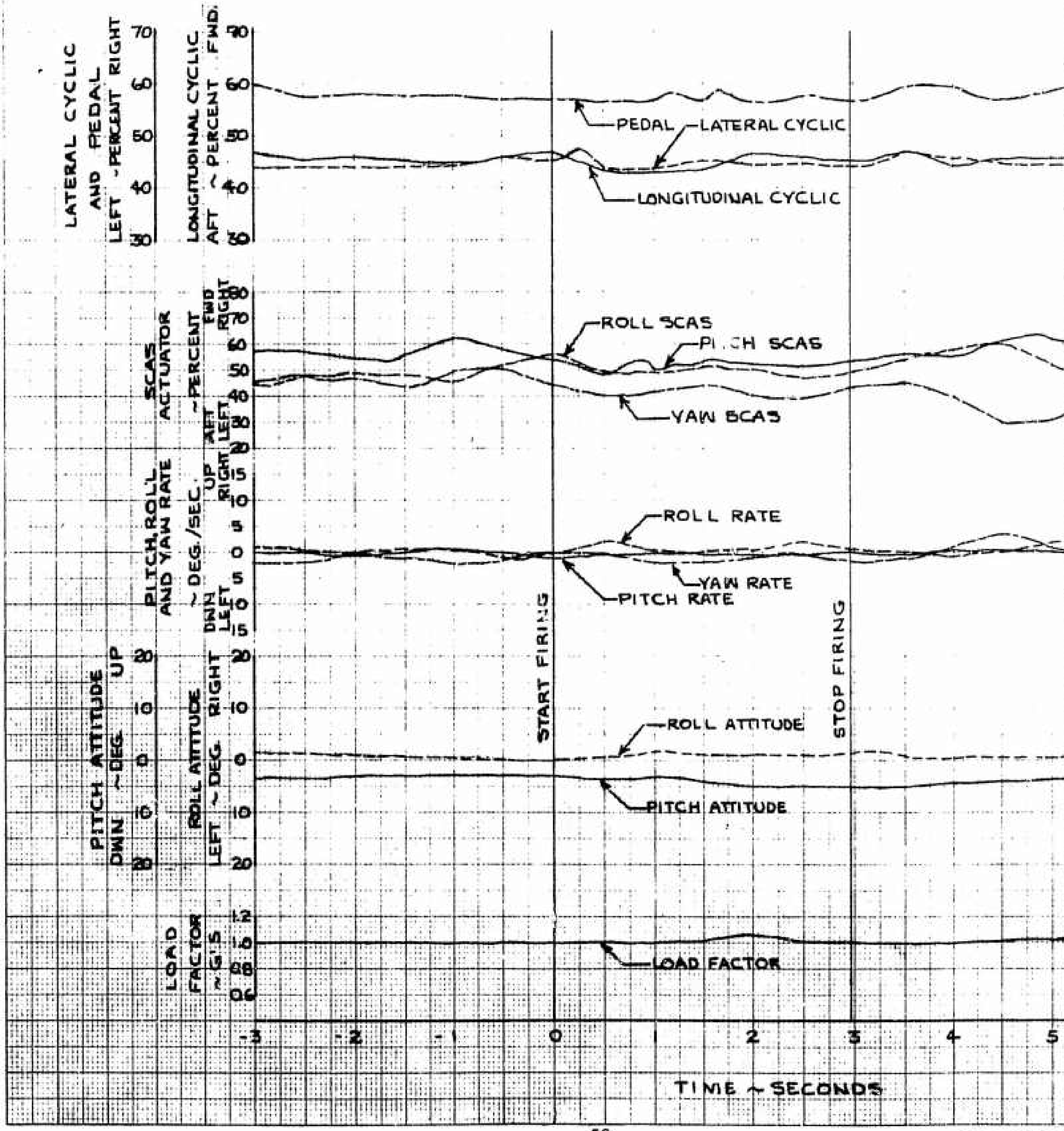
2

FIGURE NO. 28

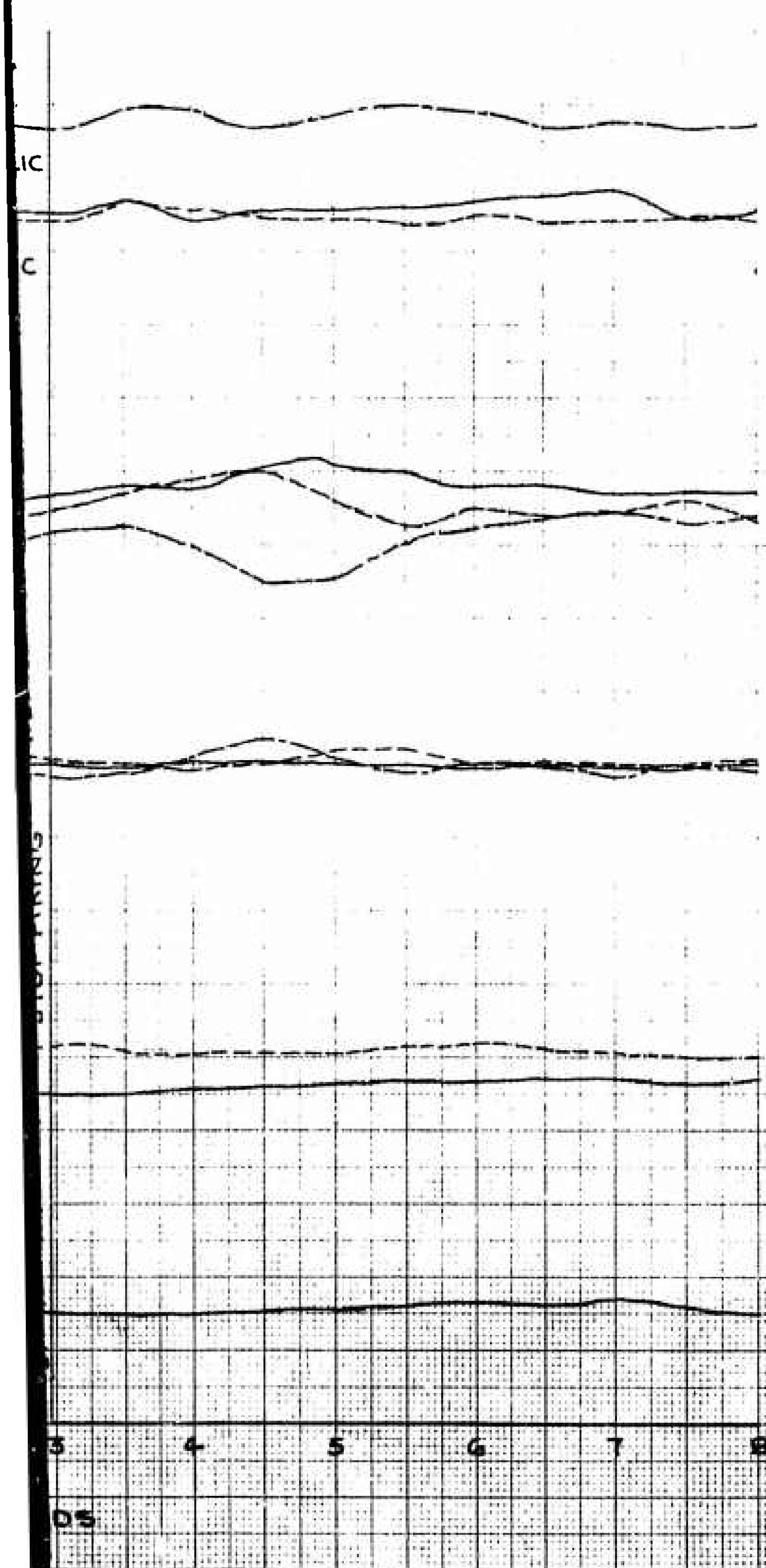
XM-159 SUBSYSTEM (OUTBOARD) RIPPLE FIRING

AH-1G USA S/N 615246

AIRSPEED ~KCAS	GROSS WEIGHT ~LBS.	C.G. STATION ~IN.	DENSITY ALTITUDE ~FT.	ROTOR SPE[ED] ~RPM
61.5	9330	195.2	3100	324



ITY ALTITUDE ~FT.	ROTOR SPEED ~RPM	CONFIGURATION
3100	324	HOG



NOTES:

1. FIRING DONE IN STABILIZED LEVEL FLIGHT.
2. FULL OUTBOARD COMPLEMENT (19 PAIRS) OF 2.75 INCH F.F.A.R. FIRED.

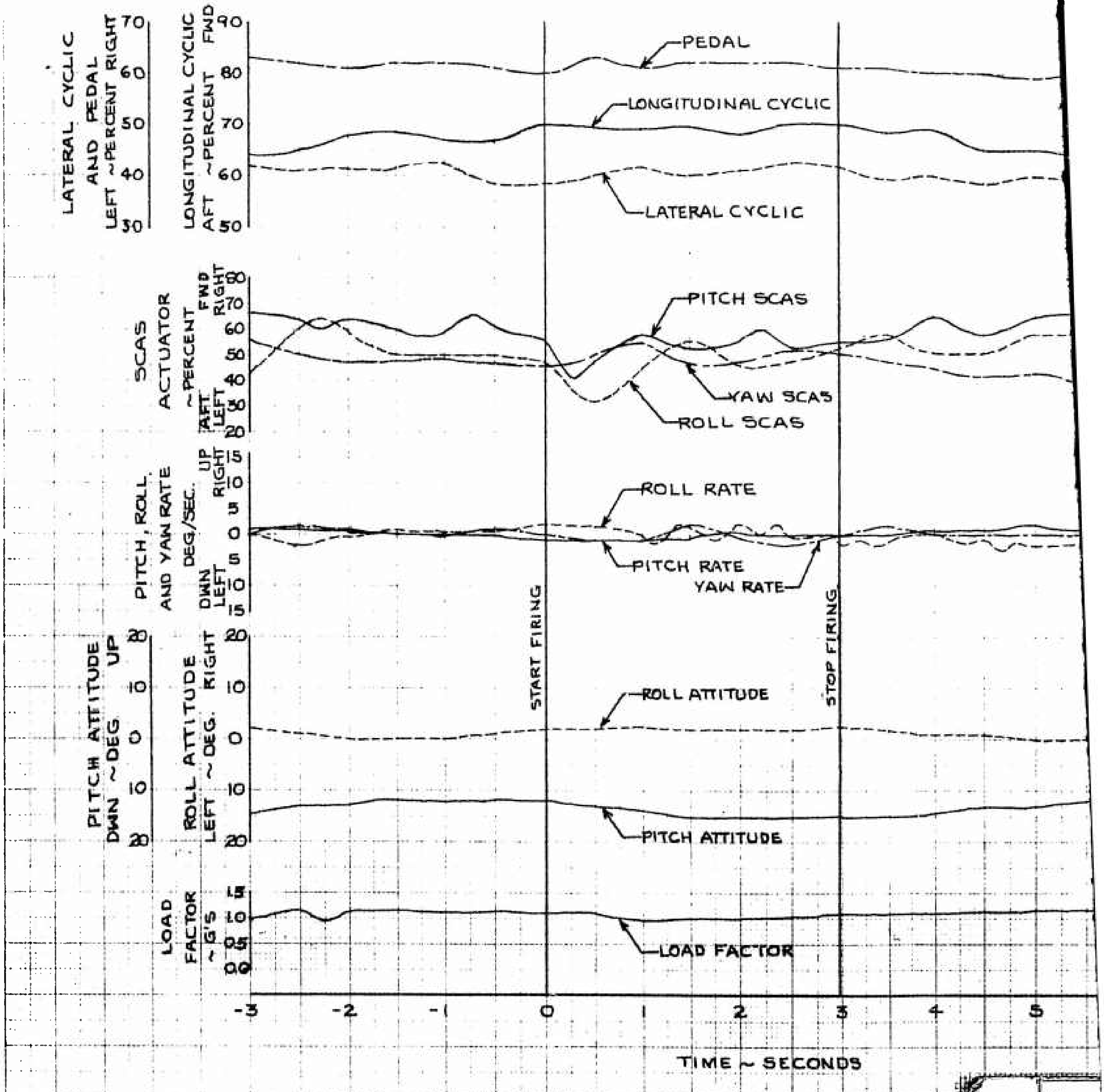
2

FIGURE No. 29

XM-159 SUBSYSTEM (OUTBOARD) RIPPLE FIRING

AH-1G USA S/N 615246

AIRSPEED ~KCAS	GROSS WEIGHT ~LBS	CG STATION ~IN.	DENSITY ALTITUDE ~FT.	RO
175	7680	194.7	3300	



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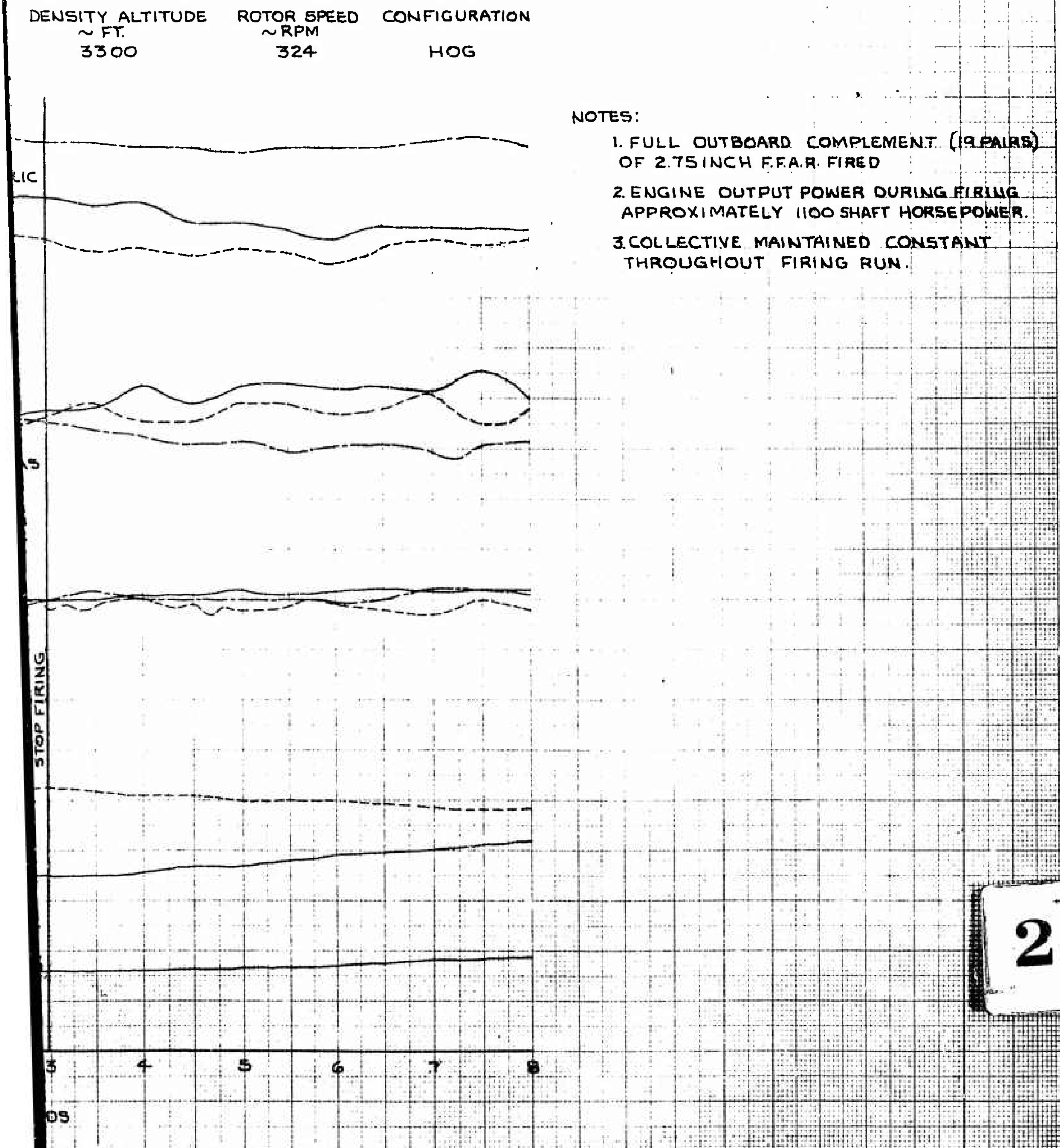
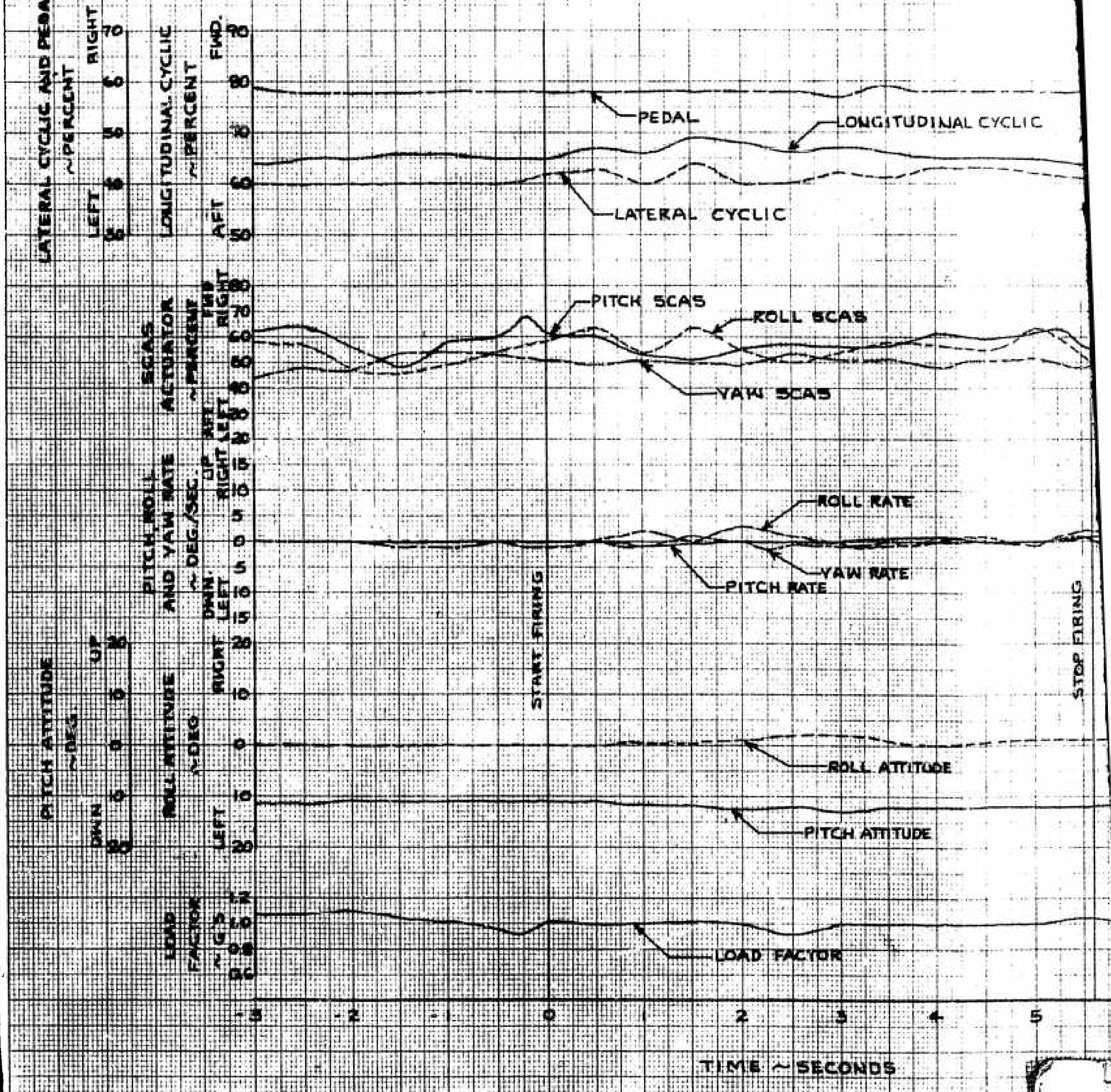


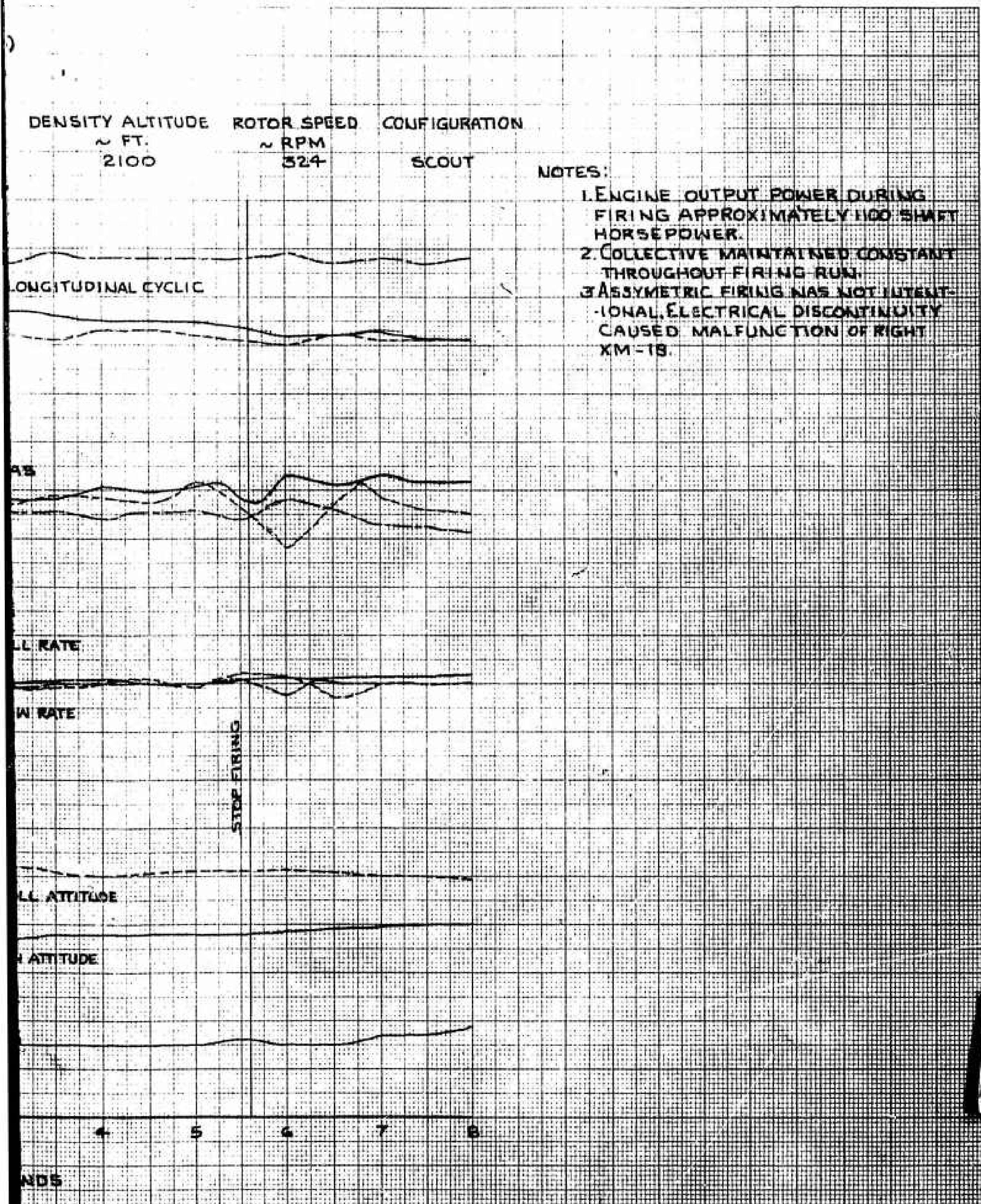
FIGURE No. 30

XM-18 SUBSYSTEM ASSYMETRIC FIRING (LEFT SIDE ONLY)

AH-1G USA S/N 615246

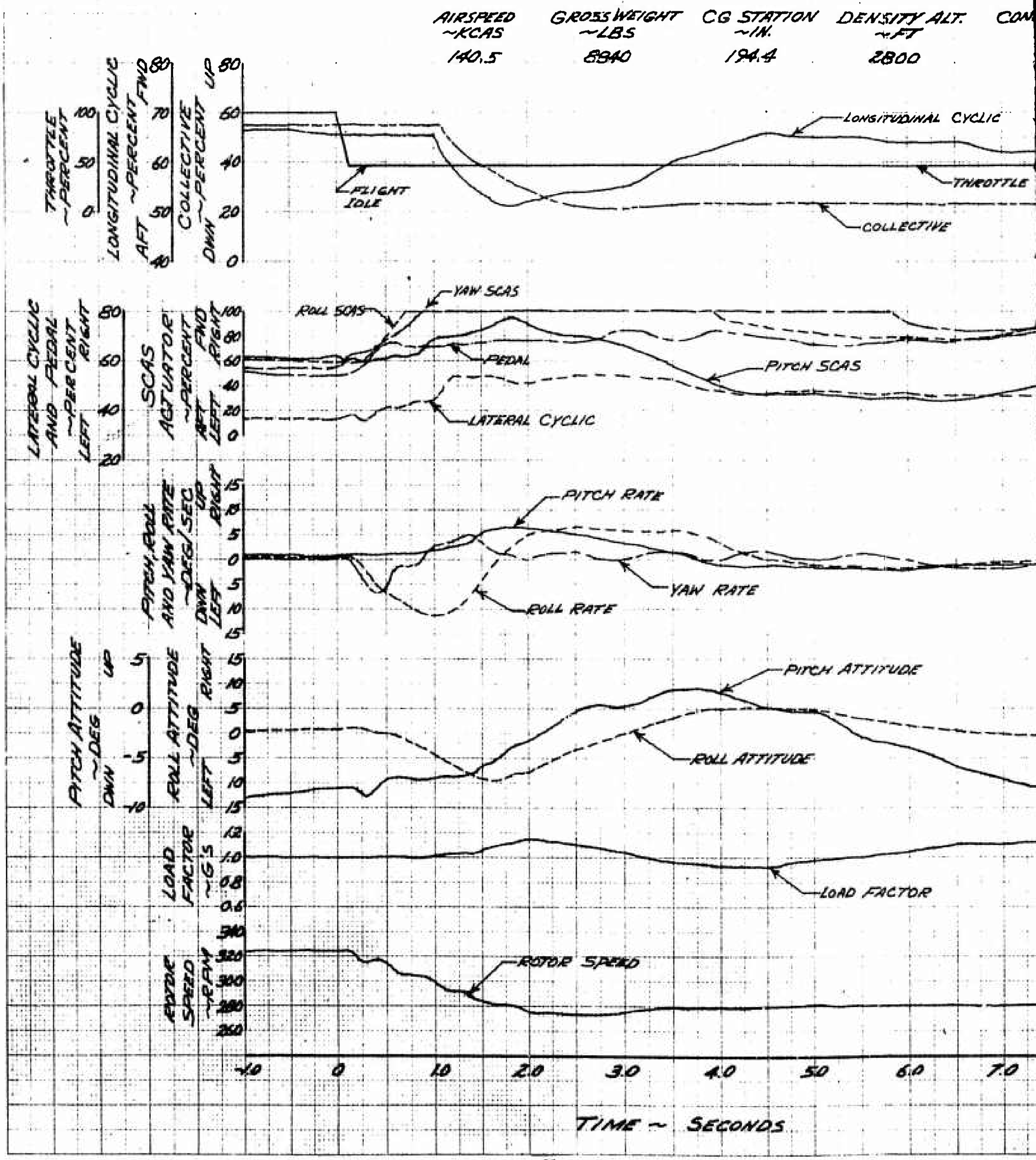
AIRSPEED ~ KCAS	GROSS WEIGHT ~ LBS	C.G. STATION ~ IN.	DENSITY ALTITUDE ~ FT.
17?.5	8740	193.7	2100

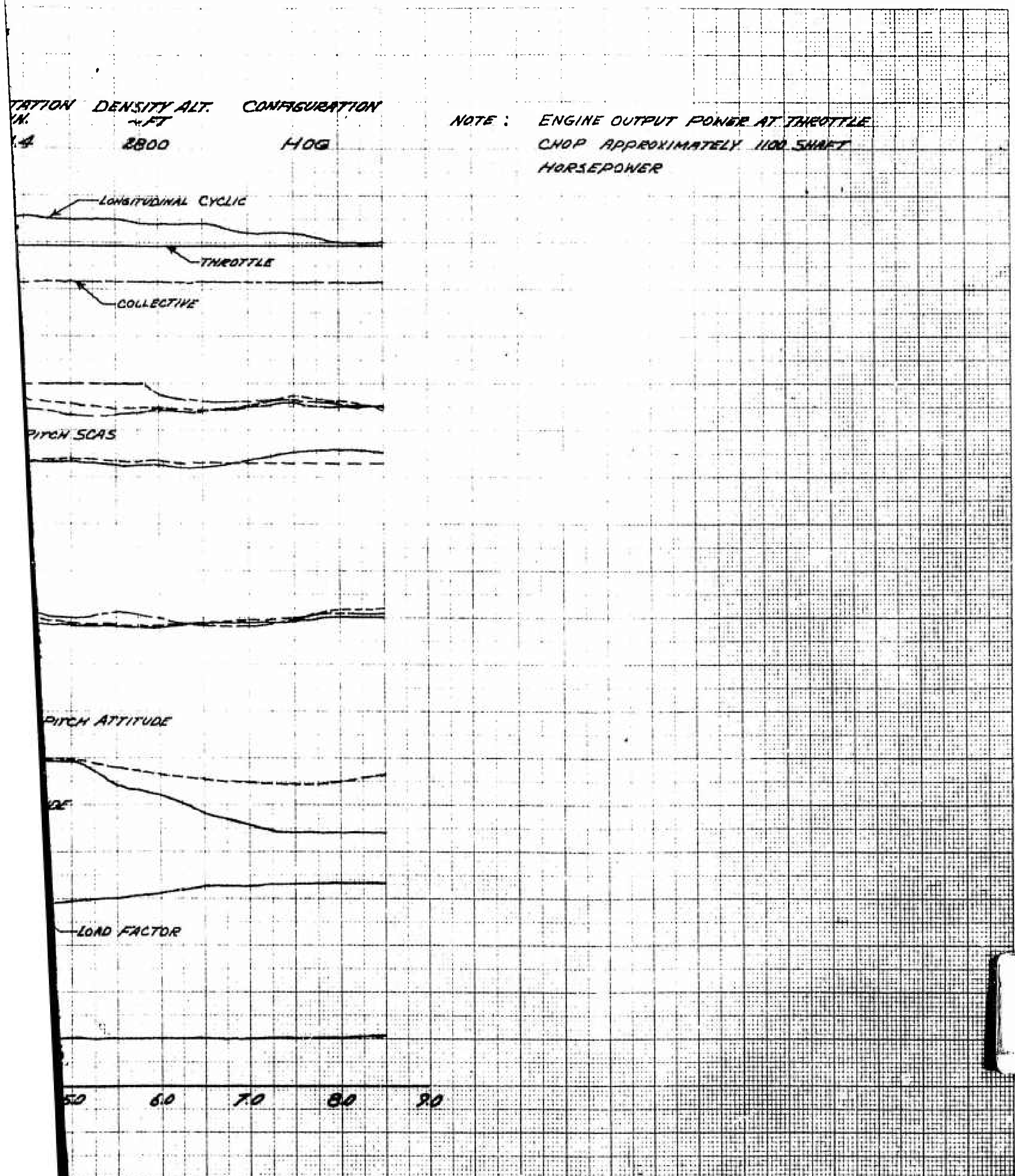



DENSITY ALTITUDE
~ FT.
2100
ROTOR SPEED
~ RPM
324
CONFIGURATION
SCOUT
NOTES:
1. ENGINE OUTPUT POWER DURING FIRING APPROXIMATELY 1100 SHAFT HORSEPOWER.
2. COLLECTIVE MAINTAINED CONSTANT THROUGHOUT FIRING RUN.
3. ASSYMETRIC FIRING WAS NOT INTENTIONAL, ELECTRICAL DISCONTINUITY CAUSED MALFUNCTION OF RIGHT XM-18.
LONGITUDINAL CYCLIC
AS
LL RATE
W RATE
STOP FIRING
LL ATTITUDE
H ATTITUDE
4
5
6
7
8
NDS

2

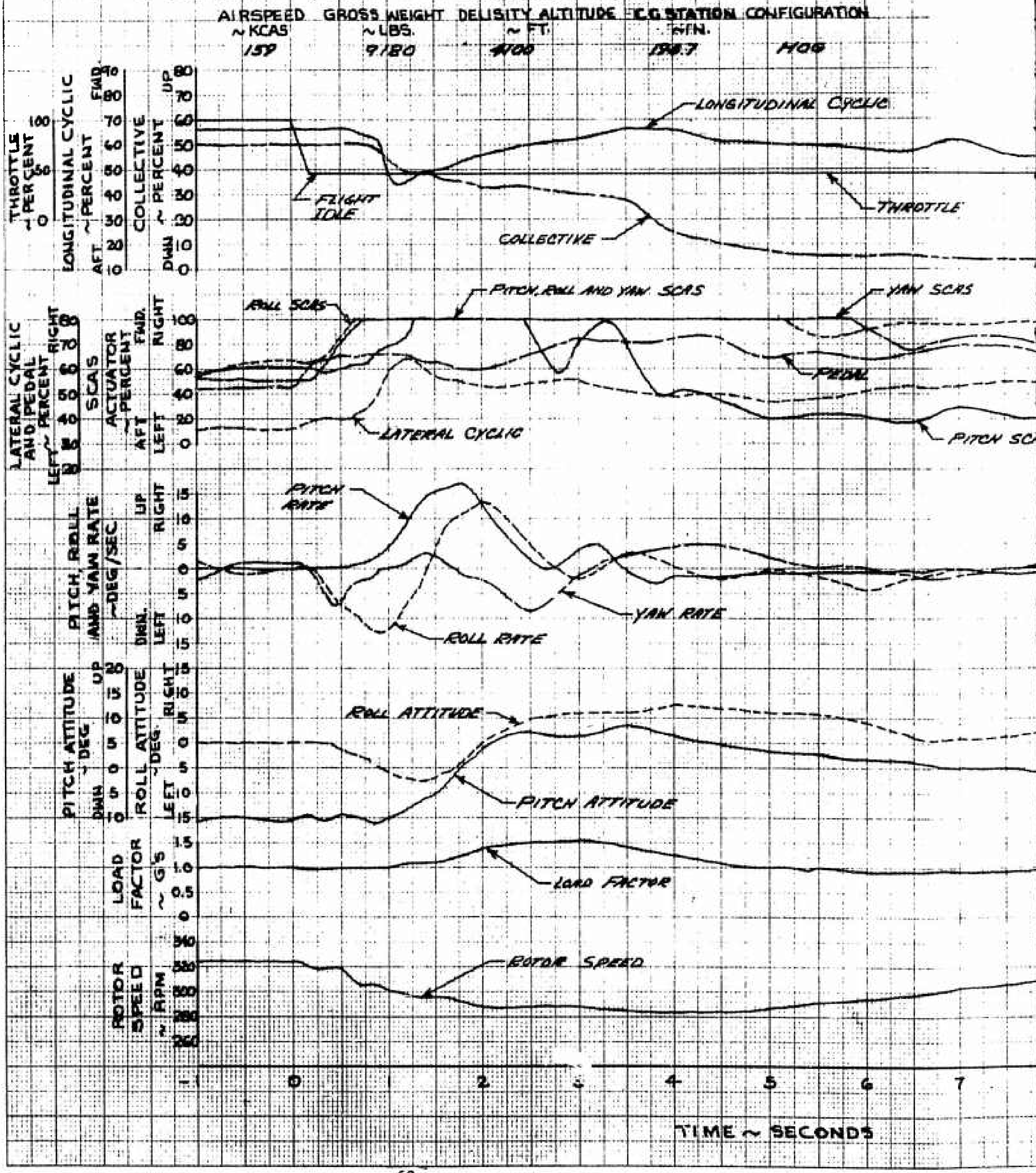
FIGURE NO. 31
THROTTLE CHOP
AH-1G USA S/N 615246

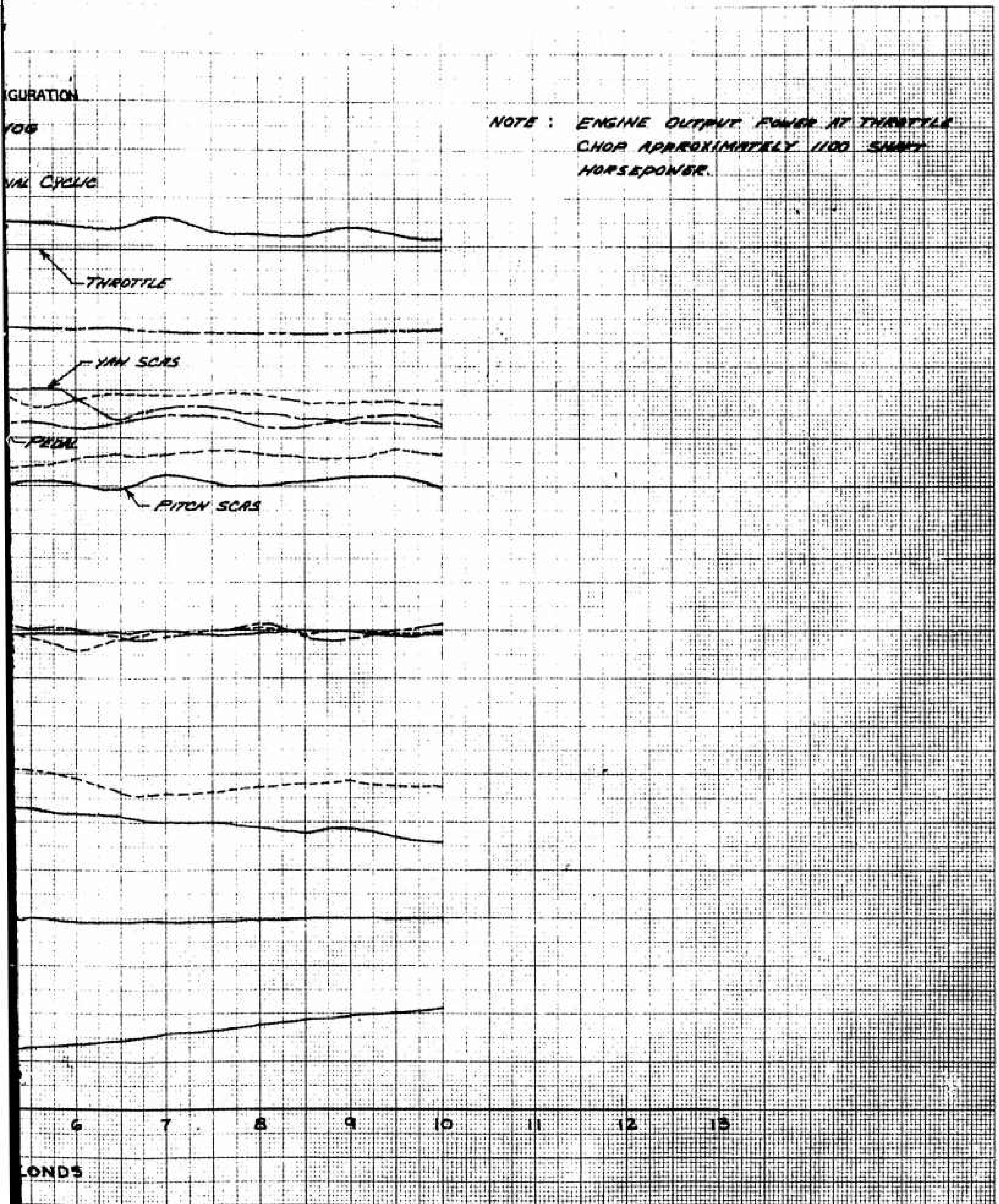



TATTION
IN.
.4
DENSITY ALT.
~FT
2800
CONFIGURATION
HOG
NOTE : ENGINE OUTPUT POWER AT THROTTLE CHOP APPROXIMATELY 1100 SHAFT HORSEPOWER
LONGITUDINAL CYCLIC
THROTTLE
COLLECTIVE
PITCH SCAS
PITCH ATTITUDE
DE
LOAD FACTOR
5.0
6.0
7.0
8.0
9.0

2

FIGURE No. 32
THROTTLE CHOP
AH-1G USA S/N 615246

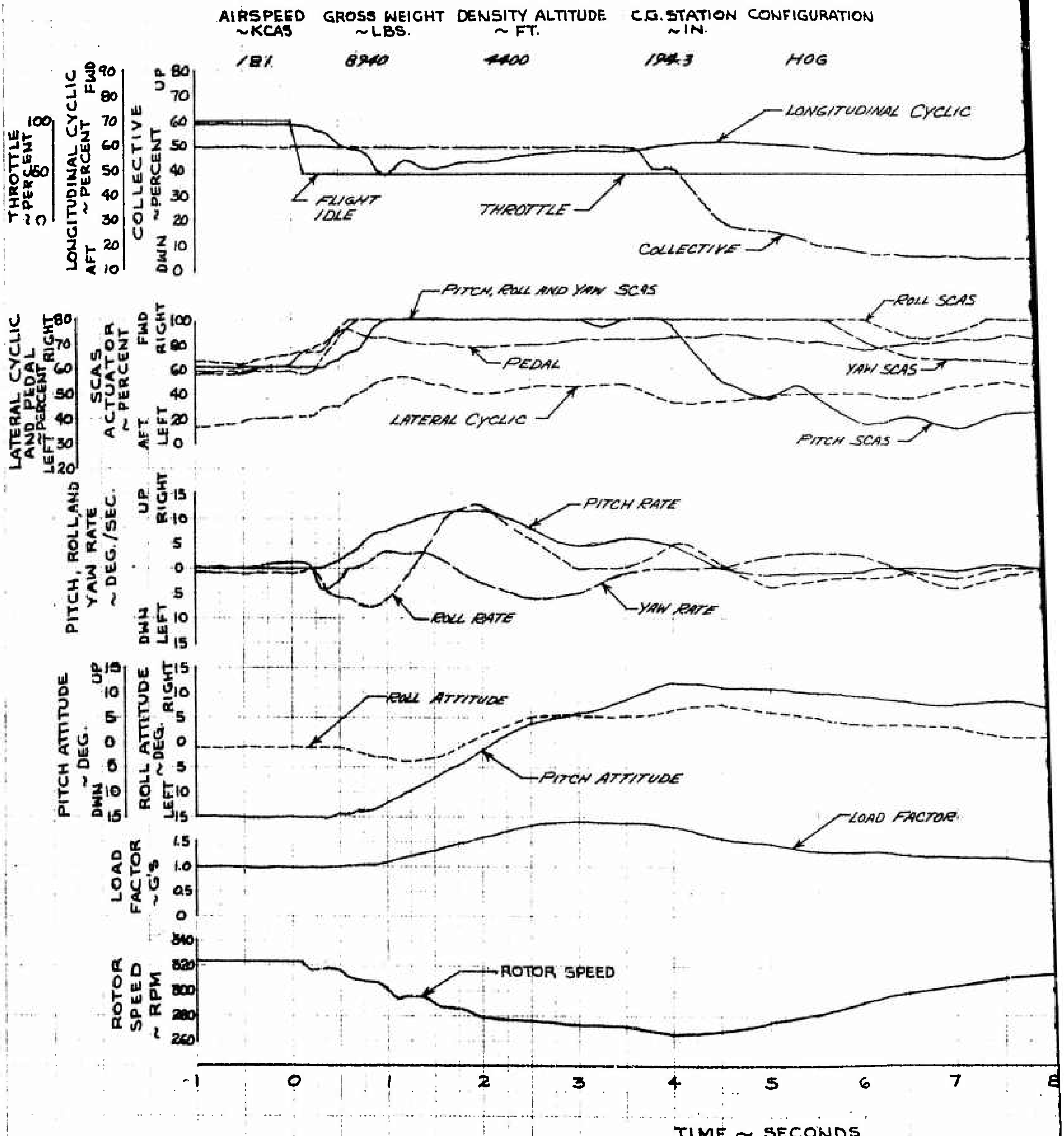


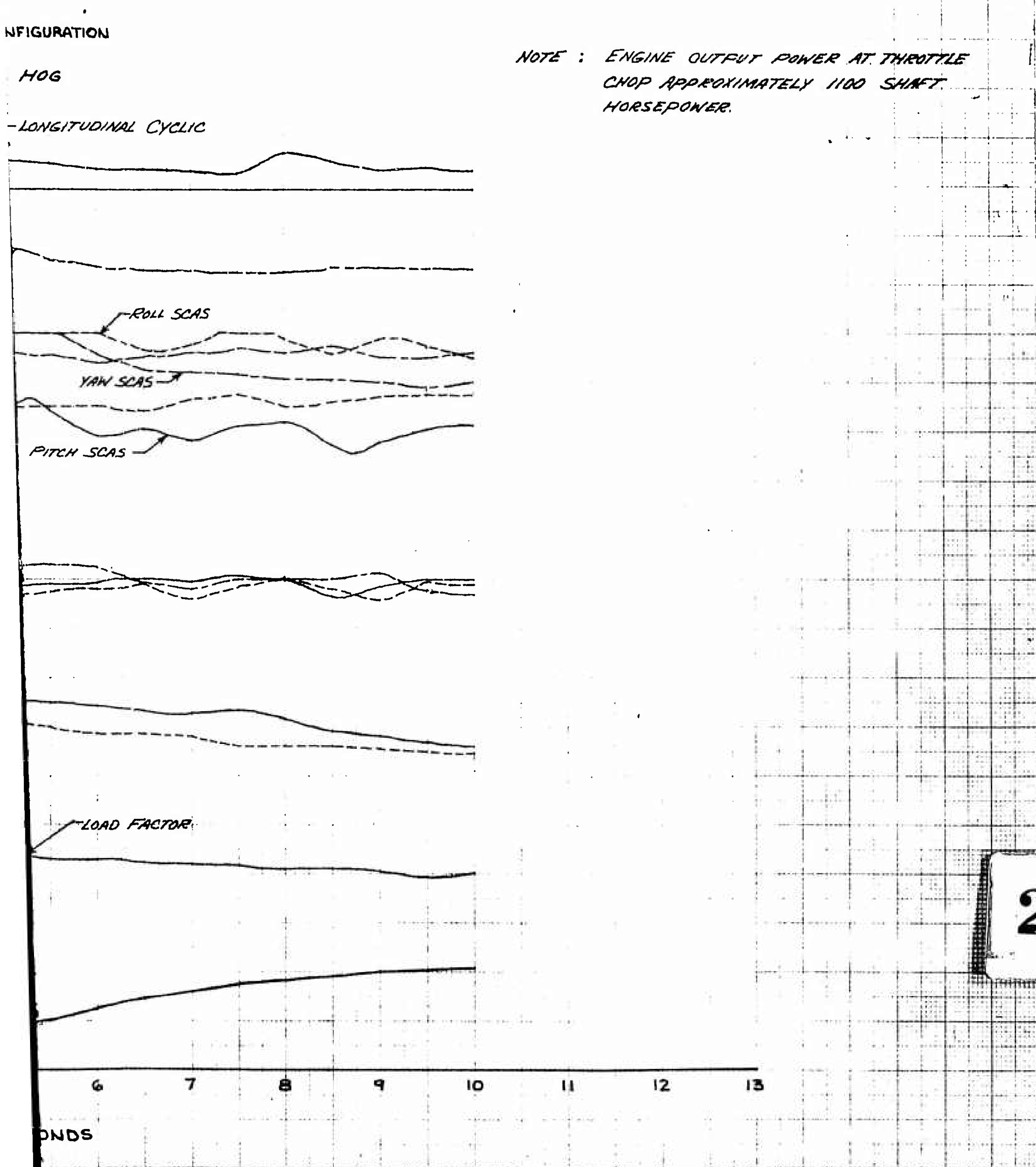


IGURATION
IOG
NAL CYCLIC
NOTE : ENGINE OUTPUT POWER AT THROTTLE CHOP APPROXIMATELY 1100 SHAFT HORSEPOWER.
THROTTLE
YAW SCAS
PEDAL
PITCH SCAS
6
7
8
9
10
11
12
13
CONDS

2

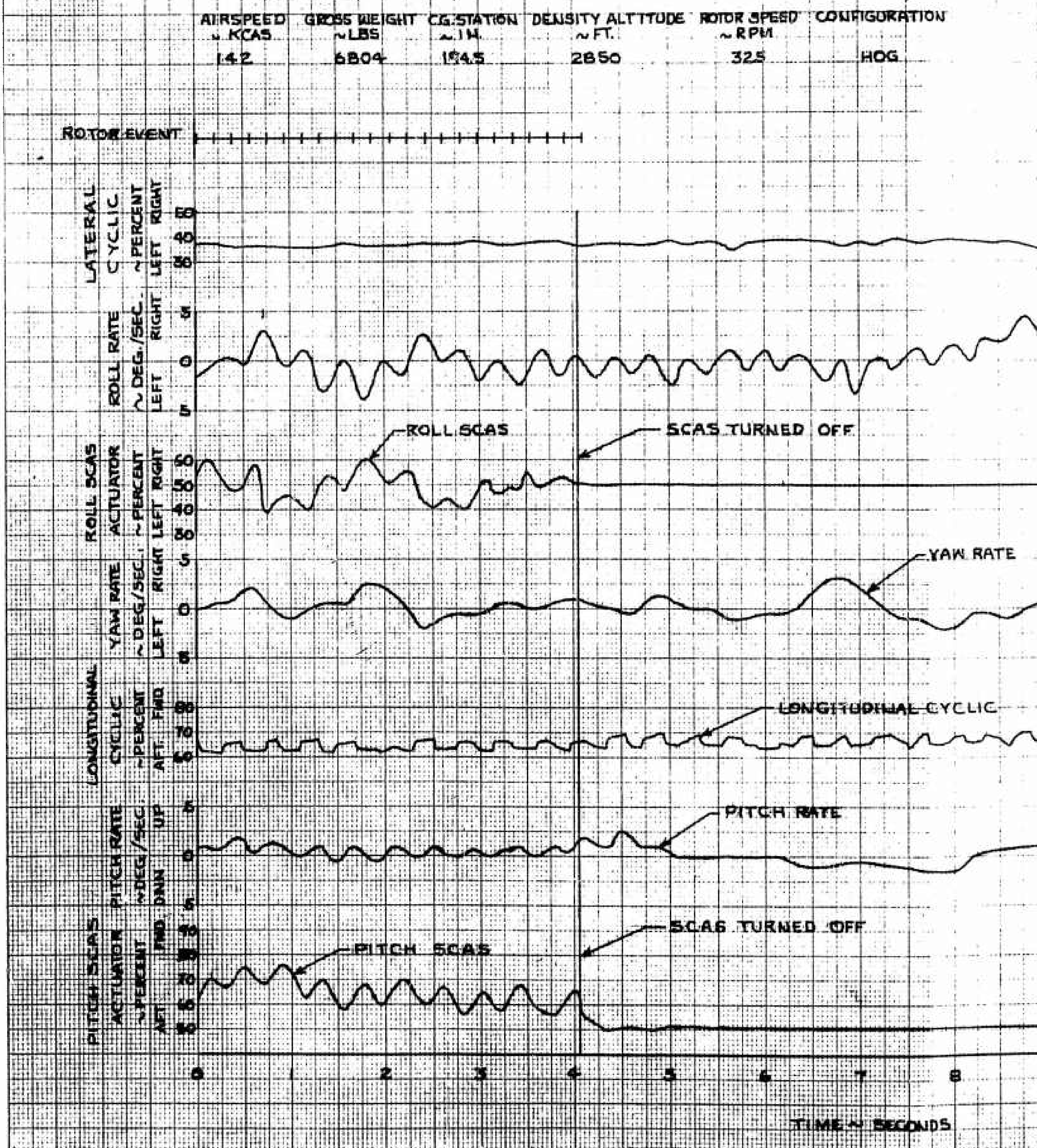
FIGURE No. 33
THROTTLE CHOP
AH-1G USA S/N 615246

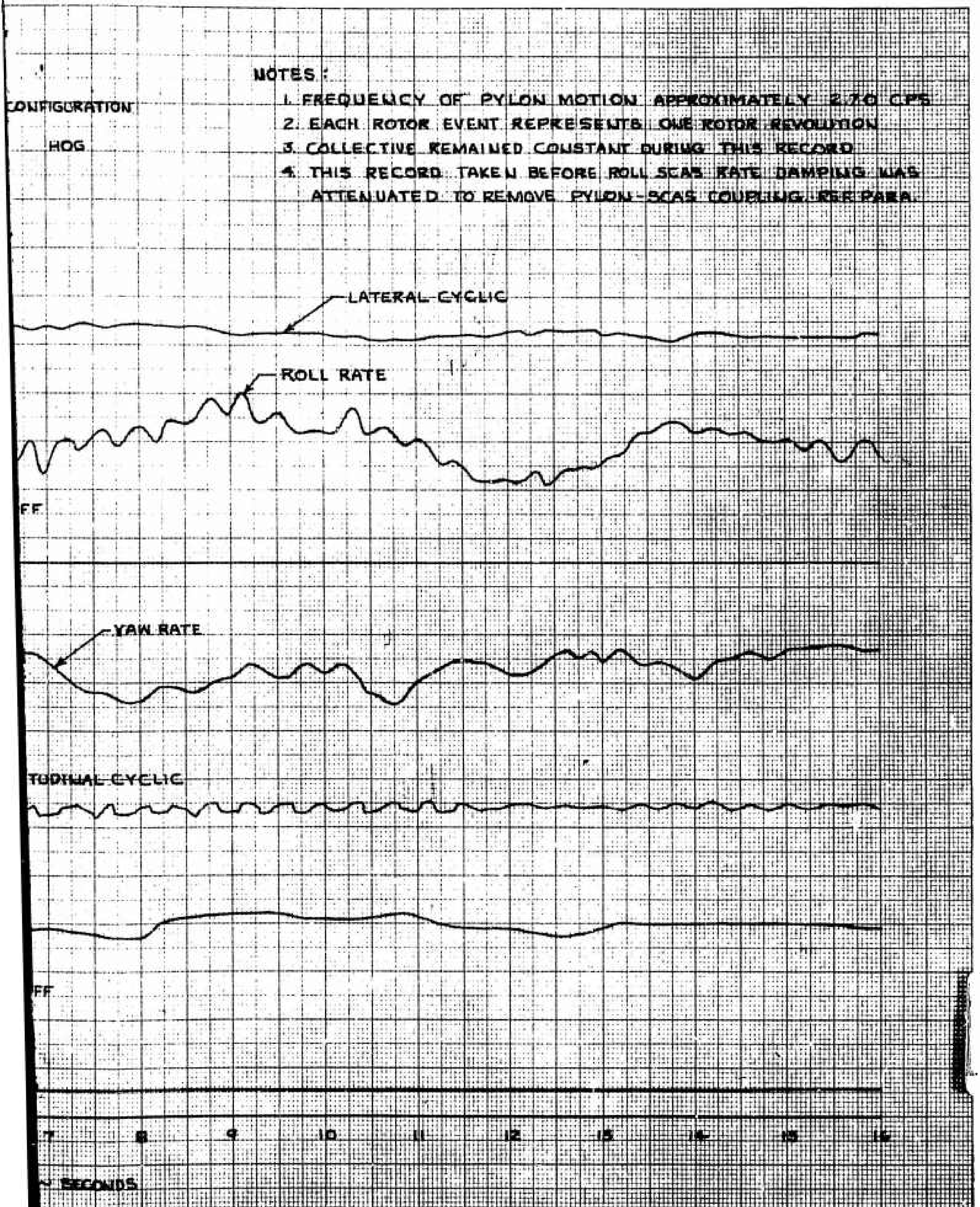




NFIGURATION
HOG
-LONGITUDINAL CYCLIC
NOTE : ENGINE OUTPUT POWER AT THROTTLE CHOP APPROXIMATELY 1100 SHAFT HORSEPOWER.
ROLL SCAS
YAW SCAS
PITCH SCAS
LOAD FACTOR
6
7
8
9
10
11
12
13
ONDS

FIGURE No. 34
SCAS-COUPLED PYLON MOTION
AH-1G USA S/N 615246




NOTES:
1. FREQUENCY OF PYLON MOTION APPROXIMATELY 2.70 CPS
2. EACH ROTOR EVENT REPRESENTS ONE ROTOR REVOLUTION
3. COLLECTIVE REMAINED CONSTANT DURING THIS RECORD
4. THIS RECORD TAKEN BEFORE ROLL SCAS RATE DAMPING WAS ATTENUATED TO REMOVE PYLON-SCAS COUPLING. REF PARA.
CONFIGURATION
HOG
LATERAL CYCLIC
ROLL RATE
FF
YAW RATE
TUDINAL CYCLIC
FF
7
8
9
10
11
12
13
14
15
16
~ SECONDS

2

FIGURE NO. 35

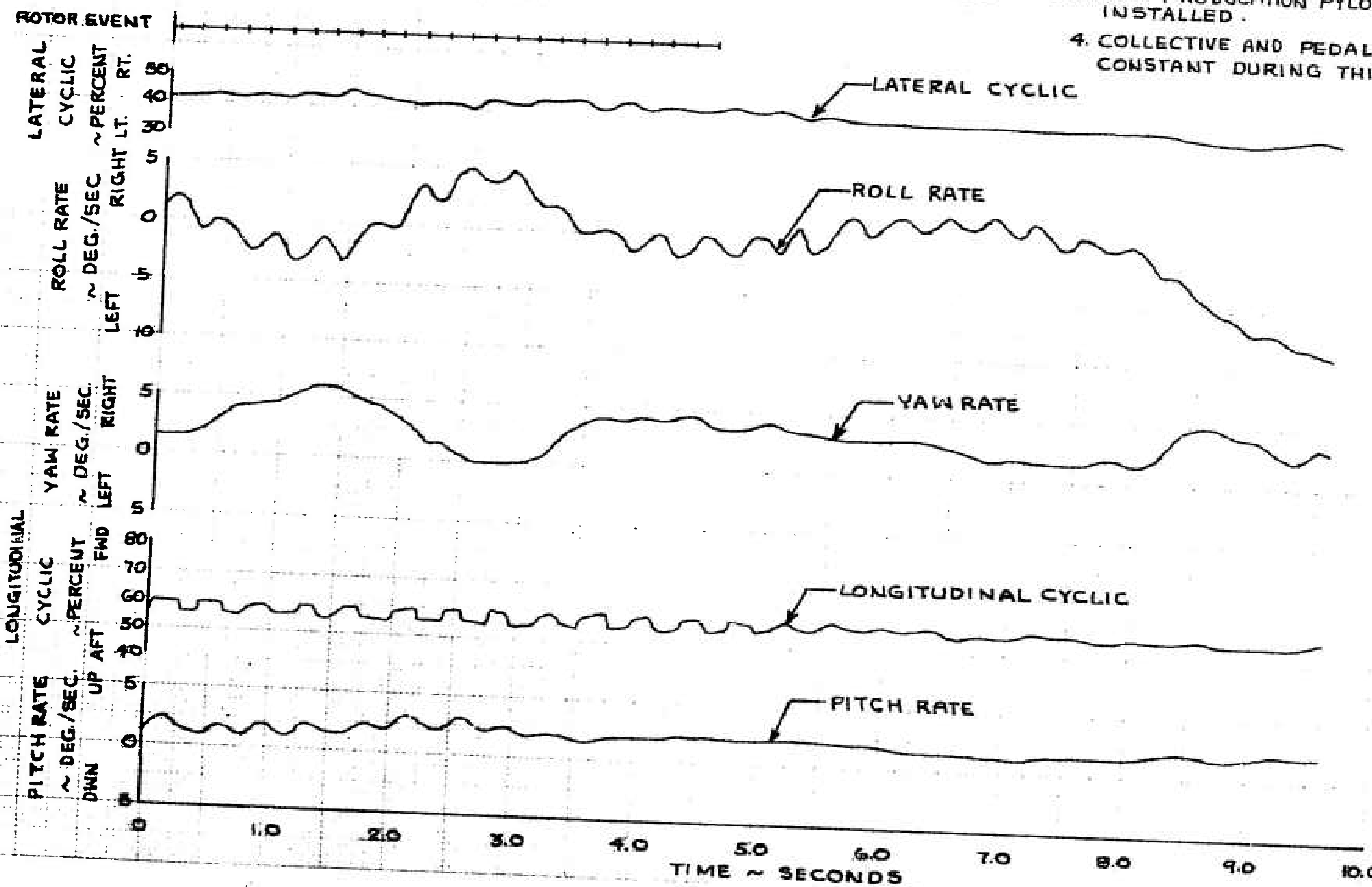
SCAS OFF PYLON MOTION

AH-1G USA S/N 615246

AIRSPEED ~ KCAS	GROSS WEIGHT ~ LBS	C.G. STATION ~ IN.	DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM	CONFIGURATION
147	8510	194.1	4300	327	HOG

NOTES:

1. THIS DATA RECORDED IN COORDINATED RIGHT TURN.
2. SCAS OFF
3. NEW PRODUCATION PYLON DAMPERS INSTALLED.
4. COLLECTIVE AND PEDAL REMAINED CONSTANT DURING THIS RECORD.



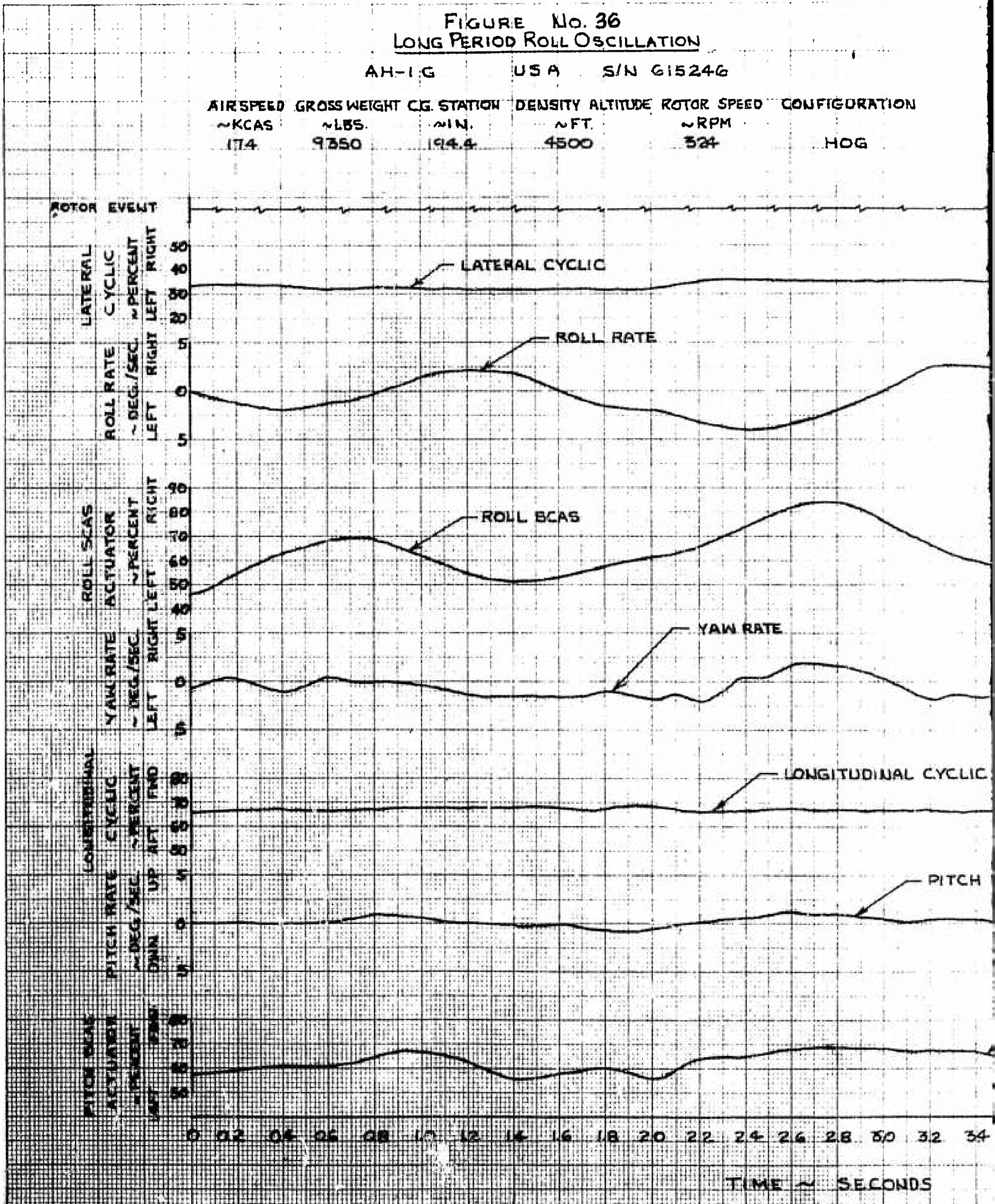
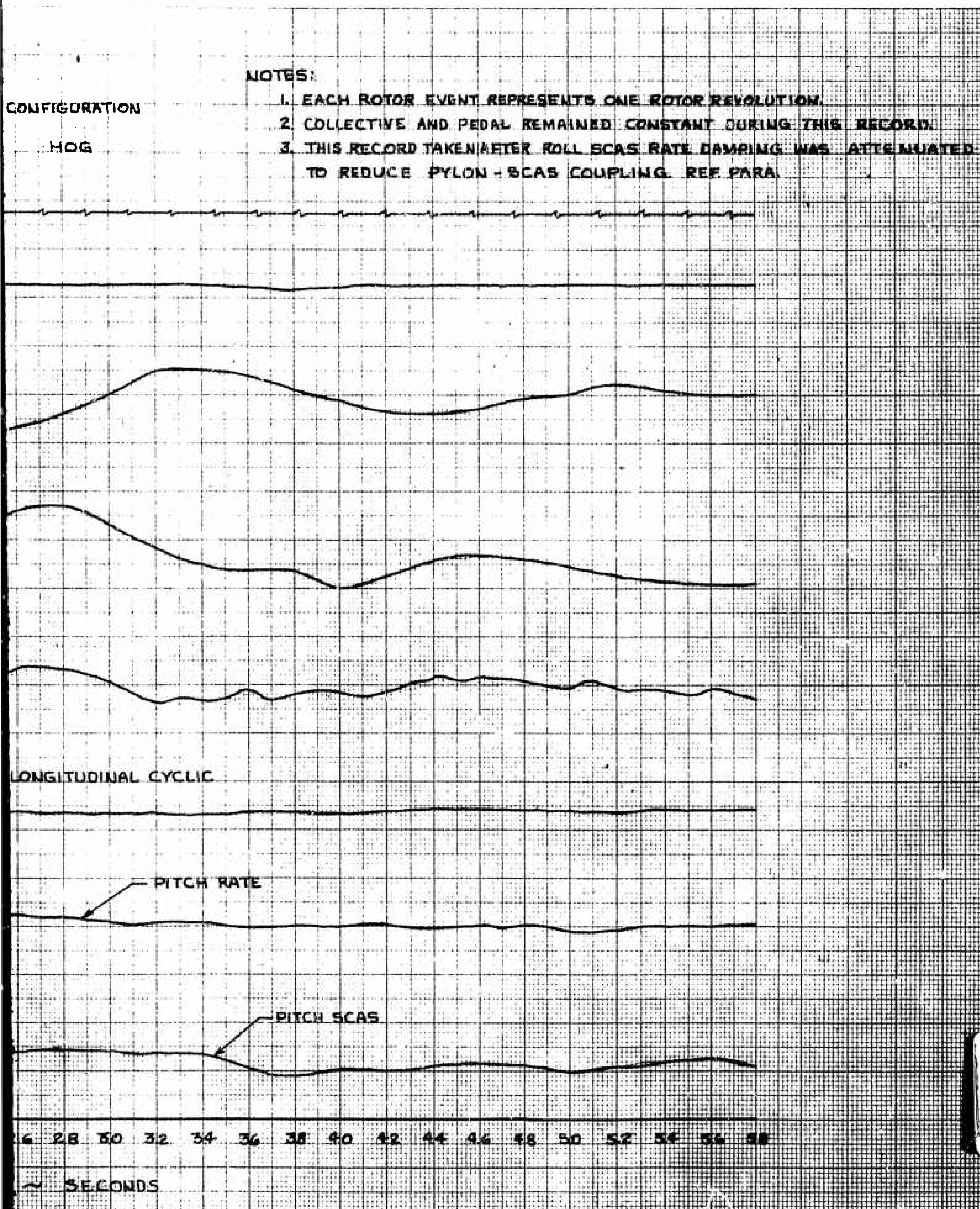


FIGURE No. 36
LONG PERIOD ROLL OSCILLATION
AH-1G USA S/N 615246
AIRSPEED ~KCAS 174
GROSS WEIGHT ~LBS. 9350
C.G. STATION ~IN. 194.4
DENSITY ALTITUDE ~FT. 4500
ROTOR SPEED ~RPM 324
CONFIGURATION HOG
ROTOR EVENT
LATERAL CYCLIC ~PERCENT LEFT RIGHT
ROLL RATE ~DEG./SEC. LEFT RIGHT
ROLL SCAS ACTUATOR ~PERCENT LEFT RIGHT
YAW RATE ~DEG./SEC. LEFT RIGHT
LONGITUDINAL CYCLIC ~PERCENT AFT FWD
PITCH RATE ~DEG./SEC. DWN UP
PITCH SCAS ACTUATOR ~PERCENT
LATERAL CYCLIC
ROLL RATE
ROLL SCAS
YAW RATE
LONGITUDINAL CYCLIC
PITCH
TIME ~ SECONDS


NOTES:
1. EACH ROTOR EVENT REPRESENTS ONE ROTOR REVOLUTION.
2. COLLECTIVE AND PEDAL REMAINED CONSTANT DURING THIS RECORD.
3. THIS RECORD TAKEN AFTER ROLL SCAS RATE DAMPING WAS ATTENUATED TO REDUCE PYLON - SCAS COUPLING. REF. PARA.
CONFIGURATION
HOG
LONGITUDINAL CYCLIC
PITCH RATE
PITCH SCAS
28
30
32
34
36
38
40
42
44
46
48
50
52
54
56
58
~ SECONDS

2

FIGURE NO. 37
SOUND LEVEL AT CREW STATIONS
AH-1G USA S/N 615246

AVG. GROSS WEIGHT ~ LB	C.G. STATION ~ IN.	AVG. PRESSURE ALTITUDE ~ FT.	ROTOR SPEED ~ RPM	AVG. FREE AIR TEMPERATURE ~ °C	CONFIGURATION
8230	194.4	2200	324	25.5	ALTERNATE

NOTES:

1. SOUND LEVELS MEASURED AT CREW MEMBER'S HEAD.
2. SOUND LEVELS MEASURED IN STABILIZED HOVER, LEVEL FLIGHT, AND DIVE AT 1100 SHAFT HORSEPOWER.
3. COCKPIT BLOWER ON.

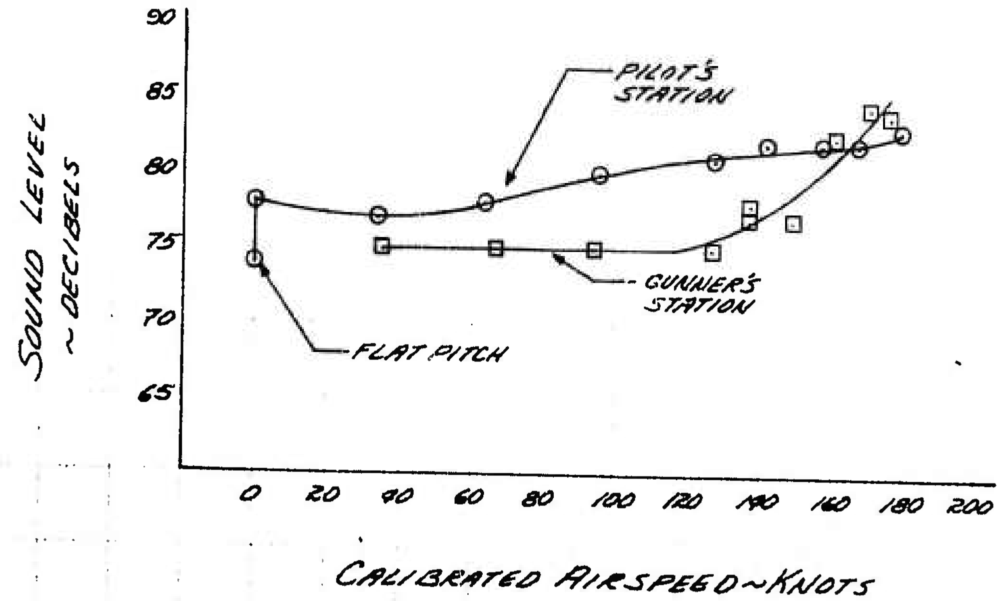


FIGURE No. 38

SYNCHRONIZE ELEVATOR MOVEMENT

AH-1G USA S/N 615246

NOTE: MOVEMENT FREQUENCY WAS PRIMARILY 2 CYCLES PER ROTOR REVOLUTION (10.8 CPS)

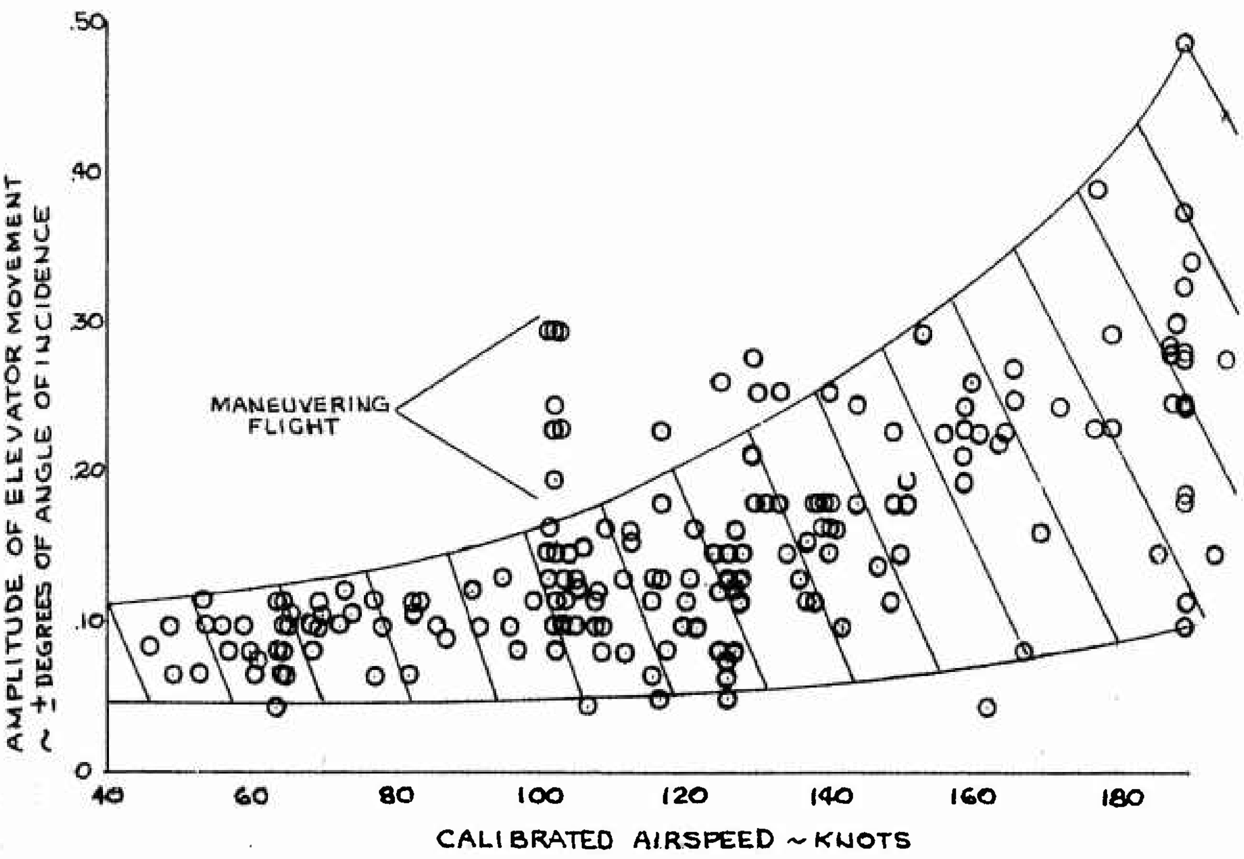


FIGURE NO. 39
LONGITUDINAL CYCLIC STICK FORCES
AH-1G USA S/N 615246

NOTES: 1. ROTOR STATIC.
2. FORCE TRIM ON.
3. FORCES MEASURED AT CENTER OF GRIP.
4. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
5. ADJUSTABLE FRICTION FULL OFF.

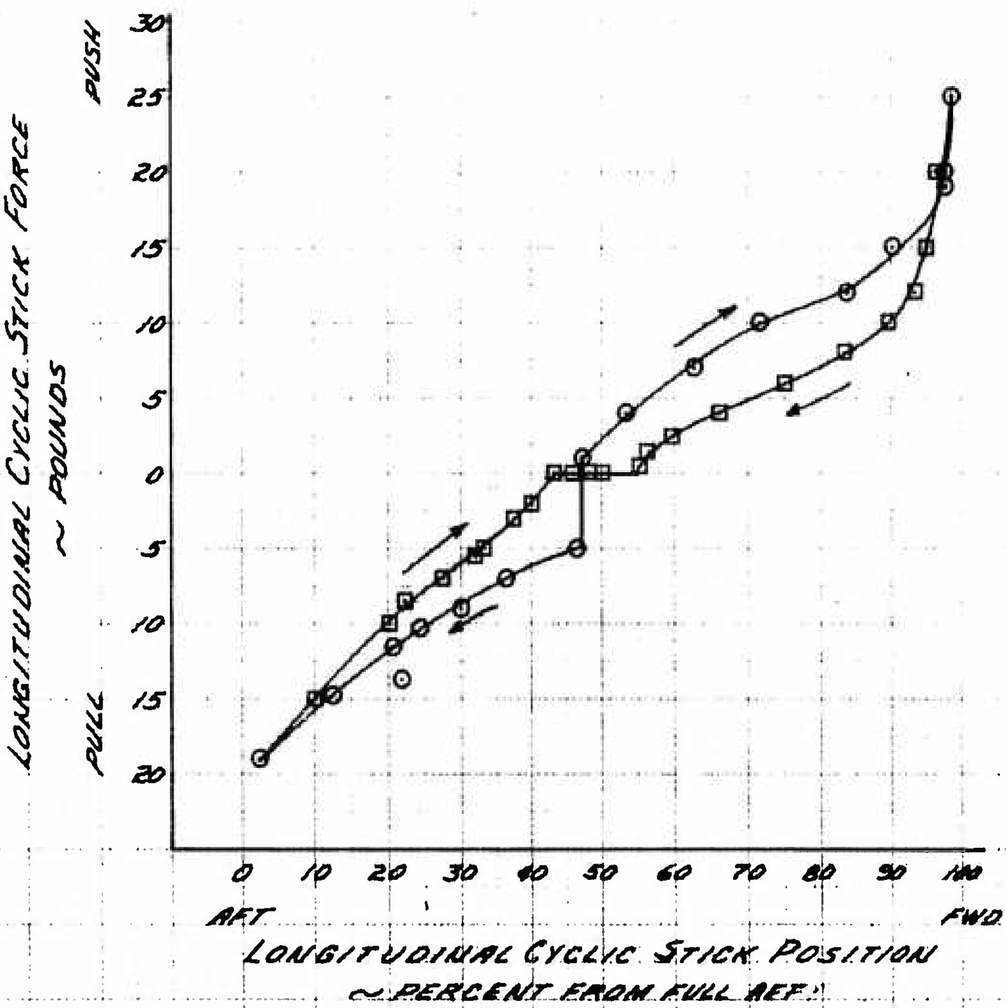


FIGURE No. 40
LONGITUDINAL CYCLIC STICK FORCES
AH-1G USA S/N 615246

NOTES: 1. ROTOR STATIC.
2. FORCE TRIM OFF.
3. FORCES MEASURED AT CENTER OF GRIP.
4. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
5. ADJUSTABLE FRICTION FULL OFF.

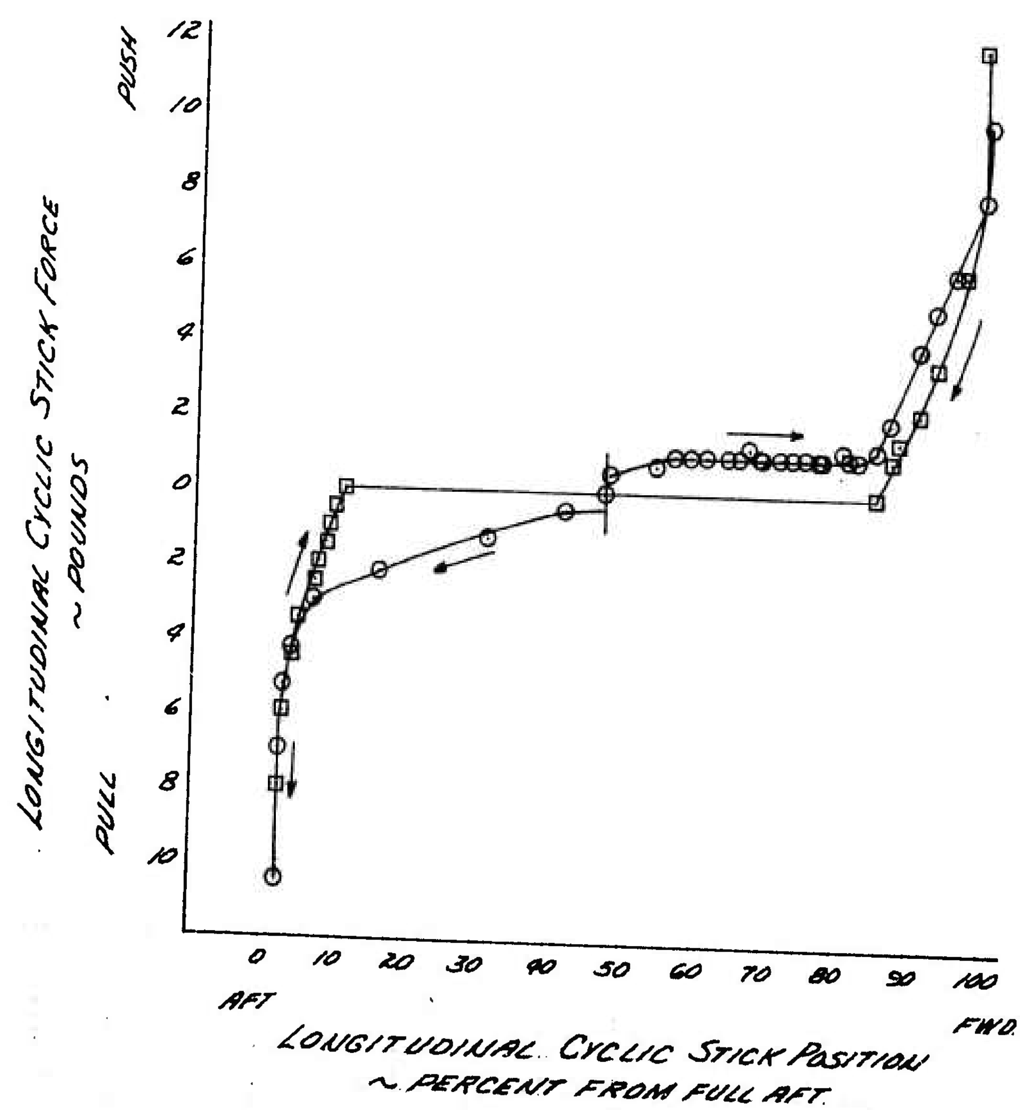


FIGURE NO. 41
LATERAL CYCLIC STICK FORCES
AH-1G USA S/N 615246

NOTES: 1. ROTOR STATIC.
2. FORCE TRIM ON.
3. FORCES MEASURED AT CENTER OF GRIP.
4. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
5. ADJUSTABLE FRICTION FULL OFF.

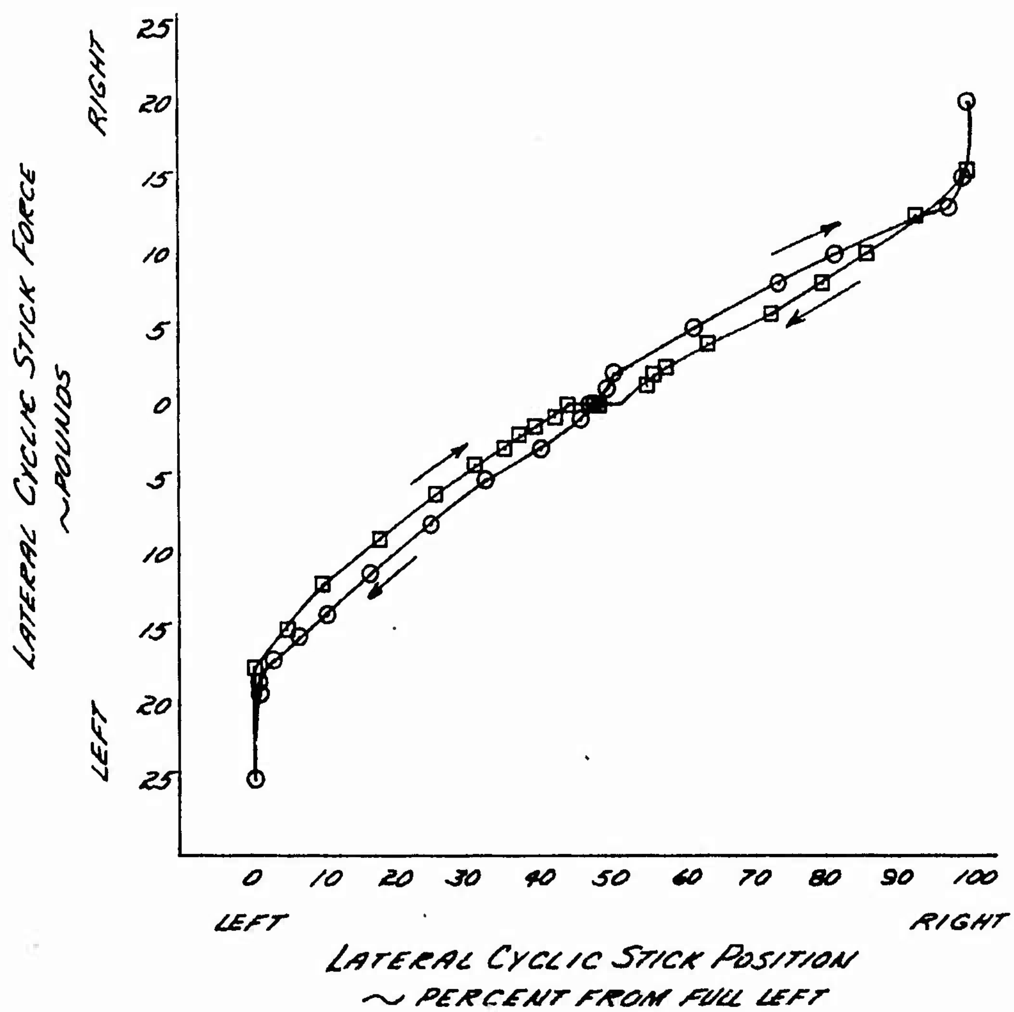
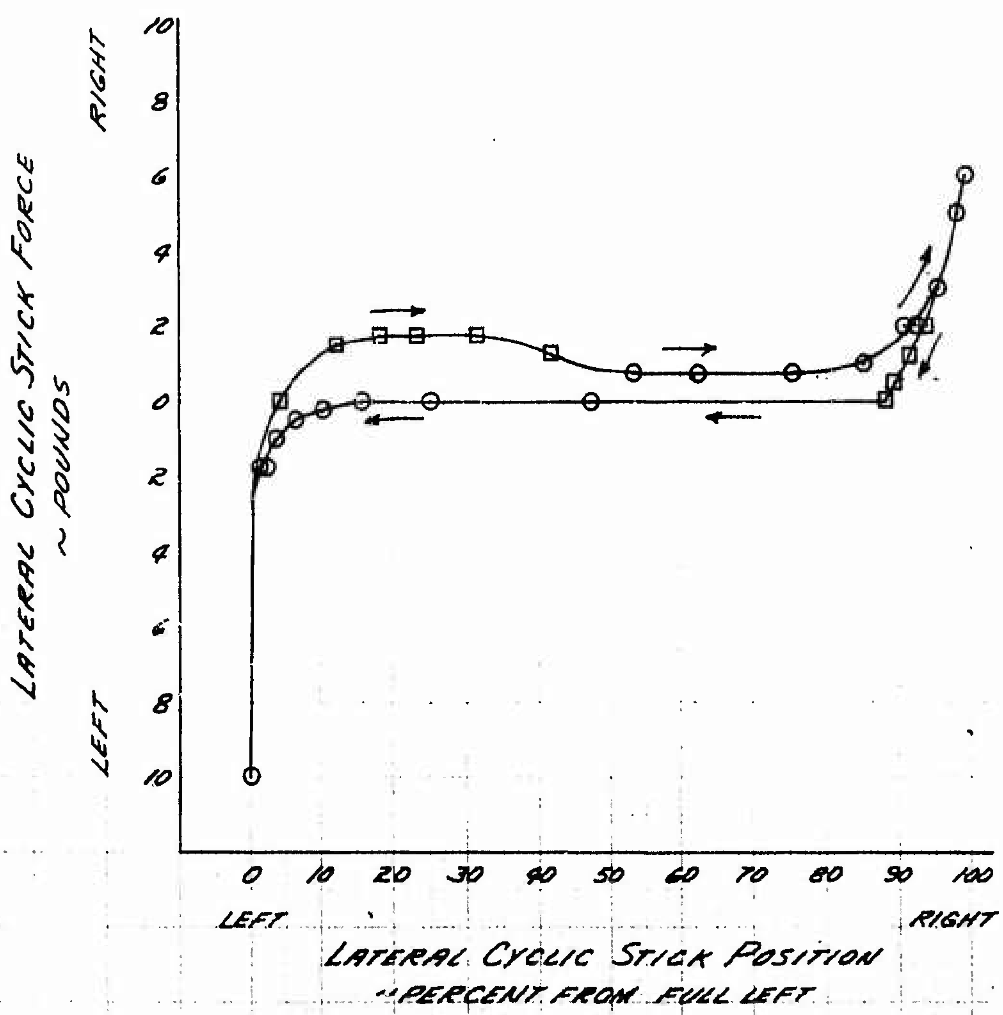


FIGURE NO. 42
LATERAL CYCLIC STICK FORCES
AH-1G USA S/N 615246

NOTES: 1. ROTOR STATIC.
2. FORCE TRIM OFF.
3. FORCES MEASURED AT CENTER OF GRIP.
4. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS.
5. ADJUSTABLE FRICTION FULL OFF.



APPENDIX II TEST INSTRUMENTATION

AH-1G HELICOPTER
Serial No. 66-15246

Flight test instrumentation was installed in the test helicopter by the contractor prior to the start of this evaluation. This instrumentation provided data from the pilot's panel, copilot/gunner's panel, and oscillograph. All instrumentation was calibrated by the contractor and witnessed or approved by the USAAVNTA flight test engineer. The flight test instrumentation was maintained by the contractor throughout the test program. The following parameters were included in the instrumentation package:

PILOT'S PANEL

Boom Airspeed
Boom Altitude
Exhaust Gas Temperature (standard indicator)
Gas Producer Speed (standard indicator)
Rotor Speed
Collective Stick Position
Longitudinal Cyclic Position
Lateral Cyclic Position
Directional Pedal Position
Angle of Sideslip
Center of Gravity Normal Acceleration

ENGINEER'S PANEL

Ship's Standard System Airspeed
Ship's Standard System Altitude
Rotor Speed (standard indicator)
Free Air Temperature
Fuel Totalizer
Oscillograph Record Counter

OSCILLOGRAPH

Control Positions (longitudinal and lateral cyclic, collective, and directional pedals)
Throttle Position
SCAS Actuator Positions (longitudinal, lateral, and directional)
Attitudes (pitch, roll, and yaw)
Angular Rate (pitch, roll, and yaw)

Center of Gravity Normal Acceleration
Angle of Sideslip
Angle of Attack
Linear Rotor Speed
Engineer's Event
Pilot's Event
Rotor Azimuth
Vibration Acceleration (pilot's and gunner's longitudinal, lateral, and vertical)
Elevator Angle of Incidence
Longitudinal Cyclic Stick Force

APPENDIX III AIRCRAFT DIMENSIONS AND DESIGN INFORMATION

OVERALL DIMENSIONS

Aircraft length (rotors turning)	52 ft 11.65 in.
Fuselage length	44 ft 5.20 in.
Maximum fuselage width (including stub wings)	10 ft 11.60 in.
Maximum fuselage width (without stub wings)	3 ft 0 in.
Width of skid gear	7 ft 0 in.
Minimum rotor ground clearance (without flexure)	7 ft 10.00 in.

MAIN ROTOR

Rotor diameter	44 ft 0 in.
Chord	2 ft 3.00 in.
Airfoil	Symmetrical Special 0009 1/3%
Twist	.455 deg/ft
Disc Area	1520.4 ft^2
Blade Area	49.5 ft^2 per blade
Solidity ratio	0.0651
Preconing angle	2.75 deg
Collective pitch travel	7.29 deg
Longitudinal cyclic travel	$\pm$14 deg
Lateral cyclic travel	$\pm$10 deg

AIRCRAFT WEIGHTS

Empty weight	5516 lb
Design gross weight	6600 lb
Maximum gross weight	9500 lb

APPENDIX IV AH-1G OPERATING LIMITATIONS

1. Limit Airspeed (V_L):

   Hog or Alternate Configuration - 180 KCAS below 3000 feet density altitude. Decrease 8 KCAS per 1000 feet above 3000 feet.

   All Other Configurations - 190 KCAS below 4000 feet density altitude. Decrease 8 KCAS per 1000 feet above 4000 feet.

2. Gross Weight - Center of Gravity Envelope:

   Forward Limit: Below 7000 lbs, Fuselage Station (F.S.) 190. Linear decrease from F.S. 190 at 7000 lbs to F.S. 192.1 at 9500 lbs.

   Aft Limit: Below 7650 lbs, F.S. 201. Linear decrease from F.S. 201 at 7650 lbs to F.S. 200 at 9500 lbs.

3. Sideslip Limits:
   Five degrees at 190 KCAS. Linear increase to 20 degrees at 60 KCAS.

4. RPM Limits (steady state):

   Power on - 6600 to 6400 engine RPM
   324 to 314 rotor RPM
   Power off- 304 to 339 rotor RPM
   transient lower limit 250 rotor RPM
   Power on during dives and maneuvers 319 to 324 RPM

5. Temperature and Pressure Limits:

Engine oil temperature	93°C
Transmission oil temperature	110°C
Engine oil pressure	25 - 100 psi
Transmission oil pressure	30 - 70 psi
Fuel pressure	5 - 20 psi

6. T53L-13 Engine Limits - Installed:

Normal rated (maximum continuous)	625°C
Military rated (30 minute limit)	645°C
Starting and acceleration (5 second limit)	675°C
Maximum for starting and acceleration	760°C
Torque pressure	50 psi

APPENDIX V REFERENCES

1. Military Specification MIL-H-8501A and Amendment 1, 3, April 1962, "Helicopter Flying and Ground Handling Qualities, General Requirements For."

2. Proposed Military Specification MIL-H-8501B, 3 June 1967, "Helicopter Flying and Ground Handling Qualities, General Requirements For."

3. USAAVLABS Technical Report 65-45, "Suggested Requirements for V/STOL Flying Qualities, "U.S. Army Aviation Materiel Laboratories, June 1965.

4. Report No. 209-947-016, "Detail Specification for Model AH-1G Helicopter, "Bell Helicopter Company, 11 July 1966.

5. USAAVNTA Engineering Flight Test Report 65-30, "Engineering Flight Evaluation of the Bell Model 209 Armed Helicopter," USAAVNTA, May 1966.

6. USAAVNTA Letter Report, "Pilot Qualitative Evaluation of Handling Qualities and Cockpit Environment of AH-1G Helicopter After Contractor Optimization of Stability Augmentation System and Improvement of Cockpit Ventilation System (USATECOM Project No. 4-6-0500-01)," 23 September 1967.

7. Letter, STEAP-DS-TI, Abeerdeen Proving Ground, 13 Sept 1966, Subject: "Test Directive, Engineering/Logistical Evaluation Test of AH-1G Helicopter (Hueycobra).

8. Plan of Test USAAVNTA Project No. 66-06, "Engineering Flight Test of the AH-1G Helicopter (Hueycobra), "April 1967.

9. TM-55-1520-221-10 Operator's Manual, Army Model, AH-1G Helicopter, Headquarters, Department of the Army, April 1967.

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2b. GROUP

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John R. Melton, Project Engineer

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d.

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12. SPONSORING MILITARY ACTIVITY
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13. ABSTRACT
Part 1 of the AH-1G helicopter Phase B test was conducted at Ft Hood, Texas, from 3 April 1967 to 21 April 1967 by the US Army Aviation Test Activity, Edwards AFB, California. The helicopter flying qualities were evaluated throughout the aircraft speed range for the Scout and Hog configurations at a mid-center-of-gravity location. Flying qualities were also evaluated during weapons firing and external stores jettison. The primary deficiencies detected during this test were stability and control augmentation system (SCAS)-pylon coupling, inadequate in-ground-effect (IGE) directional control power, undue pilot attention required to avoid exceeding the torque limits of the helicopter transmission in dives and left rolls with fixed collective, and an inadequate, illogical fire control system. Other shortcomings were detected, such as airspeed system errors, degradation of flying qualities with SCAS off, static lateral cyclic control force imbalance, and marginal cockpit ventilation. Helicopter reactions to weapons firing and external stores jettison were satisfactory, and the contractor approved flight envelope for firing and jettison was acceptable.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
AH-1G Hueycobra						
SCAS-Pylon Coupling						
In-Ground-Effect						
Directional Control Power						
Torque Limits						
Fire Control						
Airspeed System Errors						
Flying Qualities						
Ventilation						
Stores Jettison						

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It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.

SUPPLEMENTARY

INFORMATION

DEP... OF THE ARMY
U.S. ARMY ... T ACTIVITY
Edwards A... 93523

SAVTE-AS 4 March 1969

SUBJECT: Change Number 1 to the USAAVNTA Project No. 66-06 Final Report.

SEE DISTRIBTUION

1. In accordance with unclassified message 12-1331 from AMSAV-R-FT, subject: AH-1G Phase B Test Reports - Control Positions, 13 December 1968, the following pen and ink changes will be made:

Engineering Flight Test of the AH-1G Helicopter HUEYCOBRA, Phase B, Part 1, January 1968, appendix III (pg 75).

Was:	MAIN ROTOR	
	Collective pitch travel	7.29 deg
	Longitudinal cyclic travel	±14 deg
	Lateral cyclic travel	±10 deg
Now:	MAIN ROTOR	
	Collective:	
	Pitch full travel	11.17 in.
	Stick:	
	Longitudinal full travel	9.68 in.
	Lateral full travel	9.49 in.
	TAIL ROTOR	
	Directional:	
	Pedal full travel	6.69 in.

2. After the above change has been posted, this letter will be filed with the subject report.

FOR THE COMMANDER:

Gerald T. Yahiro

GERALD T. YAHIRO
CPT, INF
Acting Adjutant

1 Incl
Distribution